A SYNOPSIS OF THE RECENT AND TERTIARY FRESHWATER MOLLUSCA OF THE CALIFORNIAN PROVINCE, BASED UPON AN ONTOGENETIC CLASSIFICATION.

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PLATES V–VIII.[1]

GENERAL REMARKS.

The Californian Province.

The region covered in the following pages has been termed by Woodward, Tryon, Fischer, and Cooke the Californian Province. Briefly it embraces the Yukon Basin and tundras to the northward, the entire Pacific drainage of North America from Western Alaska south to the vicinity of San Sebastian Viscaino Bay, Baja California, the Great Basin, and the drainage of the Colorado River. This vast area, considered as a whole a well-defined faunal unit, may be conveniently divided into twelve systems,[2] or faunules, which correspond roughly to the principal drainage areas, viz.: *Yukon*, basin of the Yukon River and associated streams flowing into the Arctic Ocean, and tundras to the northward; *Alaska*, the Alaska Peninsula, Aleutian Islands, and coastal drainage south to the Stikine River; *Fraser*, the Fraser basin, and rivers northward to the Portland Canal, Vancouver and Queen Charlotte Islands, the Puget Sound Region, and the streams flowing north and west from the Olympic Peninsula; *Columbia*, entire basin of the Columbia River, and coastal streams from Gray's Harbour to the Umpqua River; *Utah*, basin of the extinct Lake Bonneville; *Colorado*, the Colorado River and its tributaries above the Needles or thereabouts; *Nevada*, the drainless basin of old Lake Lahontan; *Klamath*, coastal streams from the Rogue to the Redwood River, the Klamath drainage, adjacent desert basins of Eastern Oregon, and streams flowing south from Mount Shasta and westward from the Sierra Nevada Mountains, north of Yosemite Valley; *Coast Range*, the Sacremento – San Joaquin Valley, southern Sierra Nevada Mountains, coastal drainage from Mad River to Point Conception, and San Francisco Bay region; *Mojave*, the drainless basins of Owens Valley, Death Valley, Mojave Desert, and the adjacent desert regions of Southern Nevada and South-Eastern California; *Los Angeles*, coastal drainage from Point Conception to the vicinity of San Sebastian Viscaino Bay; *Arizona*, the Colorado Desert and drainage of the Colorado River below the Needles.

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[1] Plates vii and viii will appear in the next part of the 'Proceedings'.

[2] See in this connexion Dall, Pop. Sci. Mo., lxvi, p. 362, 1905; *Alaska*, xiii, 1905, p. 2; Hannibal, in *West Coast Shells*, 1910, p. 229.

Composition of the Fauna.

The Californian fauna, a summary of which is given in the accompanying tables, is a composite one and can only be understood through the Tertiary palæontological history of the region, which may be summarized as follows: —

1. Older Eocene: conditions West Indian, great interior lakes, fauna similar to that of contemporaneous deposits in Rocky Mountains, not closely related to any existing American faunas. (Payette, Truckee.)

2. Younger Eocene, Oligocene: climate continuing nearly tropical and moist, widespread estuary conditions along coast; fauna similar in aspect to preceding, marked, however, by an invasion of Unioids belonging to recent European genera. (Tejon, John Day.)

3. Miocene: conditions similar to those of Mexico, arid period, a few minor lacustrine deposits interbedded with volcanic ejectamenta, fauna consisting of Gulf States or Mexican genera, a few widespread living species first appear. (Mascall, Rosamond, Contra Costa.)

4. Pliocene: introduction of sub-boreal conditions, slightly colder than present, period of extensive lakes; peculiar portion of existing Californian fauna appears abruptly in nearly its present form, widespread recent molluscs few, however; half or more of species living; *Pyrgulopsis* represented by several peculiar species. (Kettleman, Santa Clara, Cache, Idaho.)

5. Quaternary, Recent: existing conditions, temporary periods of widespread lakes; faunas occupied present or approximately present distribution south of limits of glacial ice-sheet. North of lat. 50° the fauna contains no peculiar forms except in portions of Alaska which were unglaciated, merely more hardy and readily distributed species which have immigrated from unglaciated areas since the middle Quaternary. Most of the species which range beyond the limits of the Californian Province first appear at this time. (Lahontan, Bonneville, Le Conte, Yukon loess, various fluvial and spring deposits, species washed into marine terraces along coast.)

The living fauna is made up of four elements: (1) Peculiar species, most of which have come down from the Pliocene (*Pompholyx effusa*, *Ambloxus pliciferus*). (2) Species common to central Europe and the less Arctic portions of Californian Province which appear to have lived on from a late Miocene migration across Bering Straits (*Margaritana margaritifera* (Palæarctic origin), *Anodonta cygnea* (Californian origin). (3) Species common to Alaska and adjacent portions of Siberia, apparently remnants of a Quaternary migration across Bering Straits (*Anodonta cygnea Beringeriana*, probably Californian origin). (4) Species of European or American origin which have immigrated from the eastward at various periods, chiefly during pre-Bonneville–Lahontan times. The European species in the American Province probably date back to a middle Miocene migration (*Physa hypnorum* (European origin ?), *Planorbis antrosus* (American origin)). On the other hand, several species of Californian origin have extended their ranges southward or eastward beyond the limits of the Californian Province (*Margaritana margaritifera falcata*, *Lymnæa solida Cubensis*).

Classification employed.

Since Evolution came to be accepted as a doctrine it has been a general policy to regard mere systematic work as a thing entirely apart from the theoretical considerations of species formation. Hence, in the bulk of zoological writings to-day a treatment of one involves no co-ordination with the other, to the mutual handicap of each. The first writer to break through these trammels of convention was Alpheus Hyatt, and to him the modern classification of the Mollusca is due. In the attempts to place this Phylum upon a stable footing an ever-increasing number of students have laboured, important among whom stand Jackson, Smith, and Grabau. Diverse as were the views on species-change which these several writers held at the onset, in recording the evolutionary modifications as they exist and applying them in their systematic studies, all have arrived at essentially identical conclusions, and the genetic classification [1] has ceased to be the unsupported theories of a philosopher-scientist and become a fact. To quote Hyatt's *Law of Morphogenesis*: "A natural classification may be made by means of a system of analysis, in which the individual is the unit of comparison, because its life in all its phases, morphological and physiological, healthy or pathological, embryo, larva, adolescent, adult, and old (ontogeny) correlates with the morphological and physiological history of the group to which it belongs (phylogeny)."

Syntonia.

Various writers, including Cooke [2] and Dall,[3] have noted the occurrence, in the shells of freshwater molluscs from brackish or enclosed bodies of water subject to concentration, of malleations, plications, or scalarity among the Gastropods, arcuity and roughening among the Pelecypods, and other deviations from the types found under normal circumstances. These examples have been invariably extreme instances, however; the less striking ones pass unnoticed, since hardly a lake, pond, marsh, slough, stagnant stream, semi-estuary, or enclosed or partially enclosed body of water, contains molluscs which are not more or less subject to these aberrancies. Frequently, particularly in the arid regions of Western North America, these forms have been redescribed as separate species,[4] but in no instance are the characters inherited, though the stock may have passed through a long line of abnormal generations. The progeny under such conditions appear to be unusually liable to become abnormal likewise, but this may be explained on the basis of hereditary

[1] Recent accounts of the genetic classification and its application to Mollusca may be found in J. P. Smith, Journ. Geol., v, pp. 509–24, 1897; viii, pp. 413–25, 1900; A. Grabau, Am. Nat., xxxvi, pp. 917–45, 1902; xli, pp. 610–46, 1907.

[2] Mollusca, Cambridge Nat. Hist., vol. iii, p. 85, figs. 33, 34, 1895.

[3] *Science*, i, p. 202, 1883; Proc. Acad. Nat. Sci. Philad., p. 408, 1896.

[4] Within a year one writer, evidently of limited experience in the field, has distinguished as a distinct genus an extreme distortion of the common *Lymnæa auricularia* from this region.

susceptibility, much as tuberculosis passes from one generation to another in the human race.

Forms produced under these circumstances are legion, but appear in every instance not as possessing new characters, but the result of an accentuation of the principal environmental and evolutionary influences which affect the mollusc, hence the term *syntonia* suggested to the writer by Dr. David Starr Jordan.

The thickness of the shell normally depends, within limits, on the amount of lime in the water. Affected by these influences the variation increases, resulting in such extreme forms as typical *Lymnæa auricularia* on the one hand and the so-called *Mighelsi* on the other. *Lymnæa palustris* commonly ranges from 20 to 30 mm. in altitude, depending chiefly on the rapidity of flow of the water. Syntonic forms have been noted 50 mm. in altitude. Ordinarily *Physa fontinalis* varies from about 60° to 70° in the breadth of the apical angle according as it is found respectively in running streams or lakes.[1] In aberrant forms the breadth may be increased to 95°.

An accentuation of the evolutionary influences in the Gastropoda may produce an exaggeration of the rest periods, resulting in the development of more or less regular costæ, of the spiral striæ causing malleations, angulations, or keeling, of the inflation of the aperture (to which cause is due the remarkable typical form of *Lymnæa auricularia*, a particularly susceptible species, of which the so-called *peregra* and *catascopium* represent the normal condition), an unnatural development of the columnar fold as frequently happens in species belonging to typical *Lymnæa*, and the production of irregularities of growth such as are common in *Planorbis trivolvis*. The Pelecypoda appear to be rather less susceptible, but arcuity among the Unioids is generally due to this cause.

No two species of Mollusca are affected to a like degree or exactly in the same manner. *Lymnæa*, *Physa*, and *Anodonta*, for instance, become progressively deformed, and senile individuals show the effects most markedly. On the other hand, in *Ambloxus* it is almost impossible to obtain normal adolescent specimens of certain species, whereas the adults are but rarely aberrant.

The cause of these phenomena has been the source of much discussion. Dall held volcanic dust responsible among the Galapagos Bulimuli, and the salts concentrated in the receding waters of Lake Bonneville in the instance of the Quaternary freshwater species of Utah. Cooke suggested brackish water to account for the deformation of the Lymnæas from the Aral Sea. No one, however, has isolated the particular salt which it is evident is producing the mischief. The only salts which occur widespread or in sufficient abundance to be regarded as probabilities are those of sodium, potassium, calcium, and magnesium. Sodium and potassium salts, known commonly as white and black alkali respectively, are frequently abundant in the arid regions of the west. It has been repeatedly observed that one or the other or both may be present in

[1] Gray's Turton, p. 228, 1857.

such abundance as to cover entirely the ground in the vicinity of a pond or stagnant stream while the Mollusca are indifferently normal or affected, and when affected seldom to the degree one would expect if the distortion could be the result of the salt in question. Calcium salts, as is well known, have no deleterious effect upon molluscan life, but are a prime necessity for its existence. Magnesium compounds, on the other hand, produce remarkable physiological effects and act as poisons.

Reasoning on this basis the writer has undertaken a series of experiments with balanced aquaria which prove beyond doubt that the small quantities of magnesium salts ordinarily present in stagnant water produce these puzzling forms, and, once produced, their results are not readily overcome. Both the sulphate and the chloride appear to be equally pernicious.[1]

Whether or not other salts have similar effects has not been ascertained in every case. The eight or nine commoner ones in ordinary water produce no appreciable distortion.

SYNOPSIS OF SPECIES.

Having considered briefly the faunal subdivisions, origin and development of the fauna, method of classification, and the interfering factor, syntonia, it is now possible to proceed intelligently with an outline of the classification and distribution of the aquatic Mollusca of the Californian Province. It may be noted at the outset that the following pages are intended chiefly as a working nucleus for future papers. A monograph of the fauna would require as many years for its preparation as this synopsis has months, to say nothing of the necessity of far more extensive field-work, hence its deficiencies may be to a degree pardonable.

PELECYPODA.

Superfamily UNIONOIDEÆ (Swainson), 1840.

The ancestral form of the Naiad shell seems to have been heavy, quadrate-discoidal, zigzag sculptured, and possessing a broad, coarse hinge. From this type there has been a general tendency for the more specialized forms to acquire a smooth, thin, posteriorly elongated shell, the markings being carried back to the umbones forming the characteristic beak sculpture and towards a reduction in the breadth of the hinge, followed by a loss first of the lateral teeth, later the pseudo-cardinals, with the ultimate result of a general simplification of all the shell parts.

This *paterina* stage is not represented without some modification by any living species known to the writer. Probably the nearest approach is in such types as *Hyria corrugata*, *Quadrula undulata*, and *Rotundaria tuberculata*, in which the sculpture has been largely carried back to the umbones, a few atavistic, undulating, or broken pustulose

[1] It is probable since the salts are ionized in solution that the hydrochloric acid present in the salivary juices would change the sulphate to chloride before it entered the circulatory system.

ridges remaining, particularly on the posterior portion of the shell, while the broad hinge and the sub-quadrate shape seem to have suffered little change.[1]

In the next stage, of which *Migranaja littoralis*, *Elliptio crassidens*, and *Lampsilis luteolus* may be taken as representatives, the sculpturing has been carried back to the umbones, the shells become posteriorly elongated and the hinge-area much reduced in breadth. Forms such as *Margaritana margaritifera falcata*, *Stropitus edentulus*, and *Alasmidonta marginata* represent the next condition, in which the laterals have become obsolete, leaving the pseudo-cardinals as tubercles, while in typical *Anodonta* the shell has become elongate-elliptical, the umbones decidedly anterior, and the hinge simple, edentate, and gently curved.

This series of changes is not characteristic of any one group of Naiades, but may be observed with more or less modifications in all, irrespective of the special line of descent. In other words the entire superfamily exhibits an instance of parallel development, and the dissimilarities of the species as one sees them are due to the different stages in the series reached by that species and the degree of unequal parallelism developed by that particular line of descent compared with the whole. Since specialization without differentiation is not very valuable in classification, the shell characters become of secondary importance in the recognition of groups more comprehensive than genera.

In the anatomy, however, one finds a sound foundation on which the higher divisions may be built. Here the specialization which takes place tends to ultimately result in the production of a parasitic larva (unlike any stage in the development of the race) which must pass through a complete metamorphosis before reaching the adolescent condition, and a specialized marsupium for its development. This reaches its culmination only in such genera as *Spatha*, *Anodonta*, and *Proptera*, but all the higher forms show indications of approaching it. It is evident that parallelism likewise exists in the anatomical modifications, in that all the groups modify towards a certain definite end, yet the means by which this is accomplished are diverse, and the resulting marsupia and larvæ are not homologous but strictly analogous.

Margaritana (Margaritaninæ) represents in its anatomical features, independent of the modifications of the shell, the oldest and least differentiated type of Naiad structure. The gill-septa, which in the more specialized groups (except the Hyriinæ) coalesce completely to form the water-tubes, are present on the inner faces of each gill-lamella. These are never united, but instead regularly beaded with low-rounded papillæ lying in rows at right angles to the septa. At occasional and irregular intervals, perhaps once to a septum, its development becomes more pronounced, and one or more of the

[1] That this shape is really primitive is evident from the inspection of the young stages of almost any Unioid; cf. pl. v, fig. 7, or Lefevre & Curtis, Journ. Exp. Zool., ix, pl. iv, fig. 29, 1910.

papillæ will meet and fuse with their neighbours on the opposite lamella, forming the scattered synapticulæ which hold the gill-plates in shape. Other simple features such as the incomplete diaphragm, undeveloped siphons, indiscriminate use of all the gills as a rudimentary marsupium, and the little modified subglobular-quadrate glochidia, may be noted.

From this simple type differentiation has proceeded in at least two directions, one marked by the southern hemisphere groups, apparently represented in their simplest condition by *Hyria* (Hyriinæ), while *Spatha* (Mutelinæ ?) is a more specialized phase, the other embracing the numerous and diverse genera which occur in the Northern Hemisphere. The simplest aspect and the one least modified from the fundamental Margaritanoid structure among the latter is exemplified in *Quadrula* (Quadrulinæ), in which the interlamellar gill-connexions are completely coalesced into definite water tubes, the diaphragm fully developed, formed solely by the gills, while on the other hand all the branchiæ are retained as a simple marsupium and the glochidia remain undifferentiated. This group has apparently given rise to another closely-allied one, in which the brood-pouch has been restricted to the outer gills only. Several American genera, *Pleurobema*, *Rotundaria*, *Elliptio*, etc., belong to this division, which may be termed the Pleurobeminæ. From the Pleurobeminæ in turn no less than two stocks have arisen. One of these is represented by *Lampsilis* (Lampsilinæ), in which a portion of the outer gills in the female are permanently modified to serve as a highly organized marsupium but in which the glochidia remain simple. From this type *Proptera* (Propterinæ) has been derived, distinguished by its peculiarly modified 'axe-head' larvæ, thus representing the culmination of the evolutionary cycle in this branch of the Naiads. *Unio* (Unioninæ) represents the other stock derived from the Pleurobeminæ. Here the glochidia have advanced in specialization, becoming triangular and armed, resembling a spade-head in shape, while the simple marsupium of *Pleurobema* is retained. *Anodonta* is a specialization of this type in which the outer gills of the female become transformed into a temporary highly modified marsupium during the gravid season, having advanced *pari passu* with the modification of the glochidia, thus resulting in a condition analogous to that of *Spatha* and *Proptera*. So much for the internal structure; the problem now confronts the systematist as to how all this may be best classified.

A species in the Hyattian sense consists of a group of related individuals having a similar genetic history and possessing a tendency to evolve along strictly analogous lines. If this group may be divided into sub-groups which occupy a particular stage in the development-series, then they may be termed sub-species,[1] while a group of species

[1] This definition, while very different from that ordinarily given for a sub-species (that it represents a geographic variety), in practice amounts to approximately the same thing. Sub-species either occupy a different geographic area, a different station, or a different life-zone from the type, so far as the writer's experience goes.

derived from the same immediate stock constitutes a superspecies or 'group' of species. Similarly, a genus is a group of allied species evolving along approximately parallel lines, and a family a group of genera whose history is essentially analogous, while sub-genera and sub-families, and supergenera or 'groups' of genera and superfamilies, bear analogous relations to genera and families respectively that subspecies and superspecies do to species.

Applying these criteria to the present group it is obvious that as a whole the Naiades constitute a well-defined superfamily, the Unionoideæ, while the different development stages, of which there are nine, constitute sub-families whose relations may be graphically expressed by the accompanying diagram. These belong to five radicles, and these radicles the writer would regard as families since they are more or less equal in value and conform to the definition. Therefore, on the basis of our present knowledge the Naiades may be tentatively classified as follows:—

Superfamily UNIONOIDEÆ (Swainson), 1840.

MARGARITANIDÆ (Ortmann), 1910.

HYRIIDÆ (Swainson), 1840.
Hyriinæ, s.s.
Mutelinæ (Gray), 1847.

QUADRULIDÆ (Von Ihering), 1901.
Quadrulinæ, s.s.
Pleurobeminæ, nov.

LAMPSILIDÆ (Von Ihering), 1901.
Lampsilinæ, s.s.
Propterinæ, nov.

UNIONIDÆ, Swainson, 1840.
Unioninæ, s.s.
Anodontinæ, Swainson, 1840.

It is probable that with a knowledge of more genera than have at present been studied and made known,[1] the number of families and sub-families will be considerably increased since the internal characters of this group have specialized along a series of similar but distinct lines.

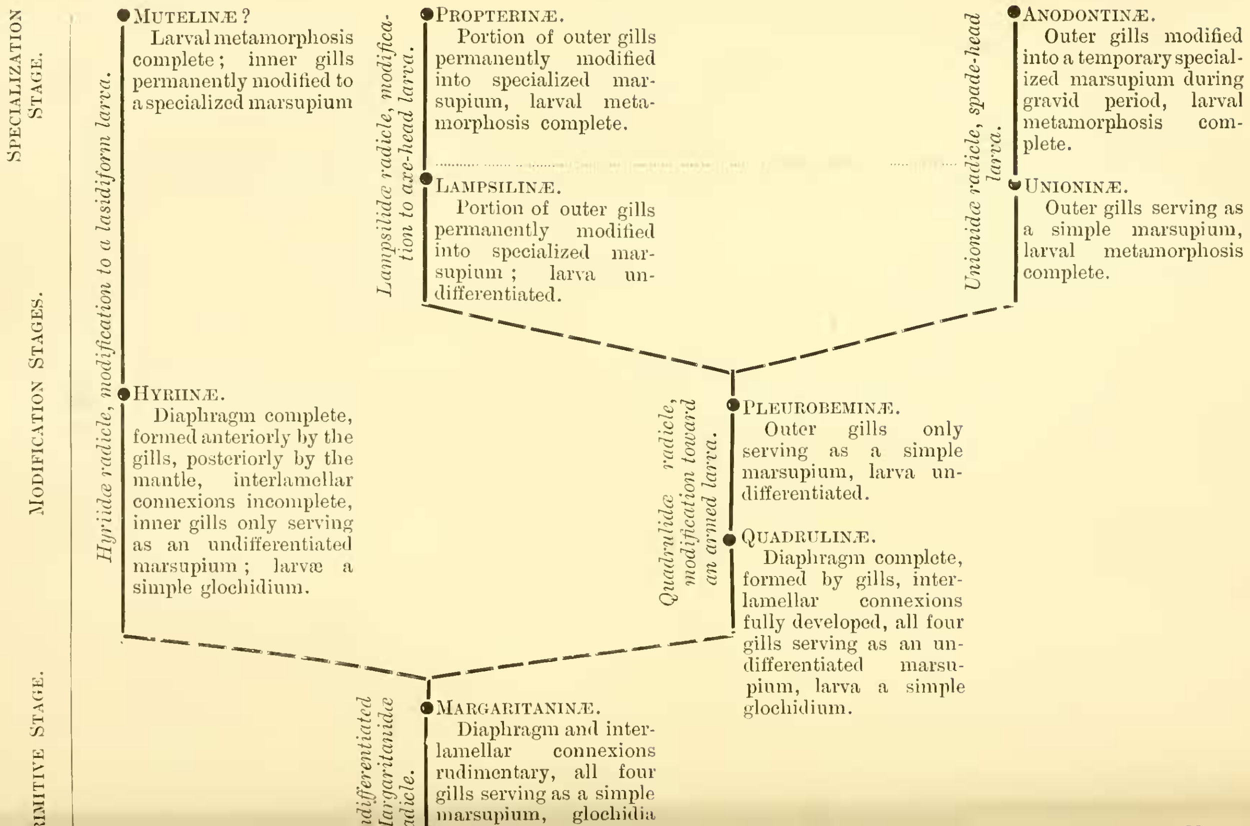
Family MARGARITANIDÆ (Ortmann), 1910.

Shell of moderately large size, quadruliform, unioniform, or margaritaniform; animal as described above, tachytictic; glochidium simple; habitat fluviatile and lacustrine.

The Margaritanidæ, in spite of the fact that modifications of the shell have taken place to a very considerable degree in all the known

[1] See A. E. Ortmann, *Nautilus*, xxiii, pp. 114 ff., 139 ff., 1910; xxiv, pp. 39 ff., 94 ff., 1910; pp. 114 ff., 1911; xxv, pp. 5 ff., 1911; Mem. Carn. Mus., iv, pp. 279–347, pls. lxxxvi–ix, 1911; Lefevre & Curtis, Journ. Exp. Zool., ix, pp. 79–115, pls. i–v, 1910.

EVOLUTIONARY CYCLE OF THE UNIONOIDEÆ (including only the groups from which data are available).



recent representatives, indicate a primitive phase of Naiad structure in so far as the anatomy is concerned.

Margaritana, the only recognized genus, appears to be confined to the Northern Hemisphere. However, *M. monodonta*, an American species, should doubtless be separated as a distinct genus; it differs in important particulars from *M. margaritifera* in the adolescent shell, a certain indication of heterogeneous origin.

Genus Margaritana, Schumacher.

Mya (sp.), Linné, 1758 (*M. margaritifera*, L.); *Unio* (sp.), Retzius, 1788 (*M. margaritifera*, L.); *Margaritana*, Schumacher, 1817 (*M. margaritifera*, L.); *Alasmodonta* (sp.), Barnes, 1823 (*A. arcuata*, Barnes=*M. margaritifera*, L.); *Damaris*, 'Leach MS.,' Gray, 1847 (*M. margaritifera*, L.), in synonymy; *Baphia*, 'Meuschen,' H. & A. Adams, 1857 (*M. margaritifera*, L.).

Type, *Mya margaritifera*, Linné.

Sub-genus Pseudunio, Haas.

Lymnium (sp.), Moquin-Tandon, 1855 (*U. sinuata*, Lam.); *Pseudunio*, Haas, 1910 (*U. sinuata*, Lam.).

Type, *Unio sinuata*, Lamarck.

Sub-genus *Pseudunio*. Shell of moderate size, averaging 120 mm. in length, sub-solid, elongate-elliptical, umbones marked by a few fine sub-nodulous ridges, moderately elevated and lying about one-third of distance from anterior extremity, lateral teeth fairly developed; nacre of concavity marked with numerous small muscle-scars; habitat lacustro-fluviatile and fluviatile.

Sub-genus *Margaritana*, s.s. Shell similar to preceding, but the lateral teeth largely or entirely obsolete; *Pseudunio* stage completed very early during adolescence; habitat running streams.

Margaritana (Pseudunio) Herrei, n.sp. Pl. VII, Fig. 17.

Margaritana '*margaritifera*, Linn.', Walker, 1910 (*partim*).

Shell rather large for genus, resembling *M. margaritifera* in general outline, but narrower and more compressed, with a straighter dorsal line; teeth not obsolete, two clavate pseudo-cardinal and two laterals of moderate length in right valve, one each in left; habitat apparently lacustrine. Length 115, breadth 40, depth of valve 12 mm.

Eocene: local freshwater beds in Tejon formation, California.

One-fourth mile above Carnegie Pottery plant, in cut along Western Pacific Railway, Corral Hollow, Tesla, California (Stanford University Geological Survey, per W. H. Ochsner) (H. Hannibal).

Named after Dr. A. C. Herre, under whose guidance the writer first became interested in the study of molluscs.

Margaritana margaritifera (Linné).

Mya margaritifera, Linné, 1758; *Alasmodonta arcuata*, Barnes, 1823 (syntonic form).

Margaritana margaritifera falcata (Gould).

Alasmodonta falcata, Gould, 1850 (syntonic form, hardly typical); *Alasmodon Yubaensis*, Trask, 1855.

M. margaritifera. Shell of moderate size, elongate-elliptical, umbones rather low, lateral teeth sub-obsolete in normal adult, nacre usually bluish or pinkish; habitat rapid streams.

Boreal portion of Palæarctic and Atlantic seabord of Nearctic regions, infrequently with *falcata* in Californian Province.

M. margaritifera falcata. Shell similar to *margaritifera*, but the lateral teeth totally obsolete, pseudo-cardinals much reduced, nacre prevailingly lurid purple or orange; *margaritifera* stage completed before mid-adolescence; habitat similar.

American Province in upper Missouri River. Fraser, Columbia, Klamath, Utah, Nevada, and Coast Range Systems.

Quaternary: Bonneville Lake beds, Utah; Lahontan Lake beds, Nevada.

The distribution of this species has been made the subject of an interesting paper by Walker.[1] The supposed Eocene record is the *Margaritana Herrei*, but the poorly preserved material then at hand from Tesla, California, showed no lateral teeth. It is probable that *M. margaritifera falcata* at no point extends south of the latitude of Monterey Bay, California.

The very young of this mollusc were once obtained, with *Sphærium*, in a little spring under the bank of a brook in which the adults were common.

Unrecognized: '*Unio* (*Margaritana*)' *onariotis*, Mayer, 1869. Miocene (?) of Alaska.

Family UNIONIDÆ, Swainson, 1840.

Shell of moderate size, unioniform, margaritaniform, or anodontiform; animal as described above; glochidium spadiform, each valve armed with a spine; habitat fluviatile and lacustrine.

Sub-family UNIONINÆ, s.s.

Shell of moderate size, unioniform or margaritaniform; animal as described above, tachylictic (?); habitat fluviatile and lacustrine.

Genera: *Unio*, *Migranaja*.

Sub-family ANODONTINÆ, Swainson, 1840.

Shell of moderate size, thin or sub-solid, unioniform, margaritaniform, or anodontiform; animal as described above, brachylictic; habitat lakes and streams.

Genera: *Anodonta*, *Gonidea*, *Arnoldina*.

The recognition of two Unionidæ, unquestionably congeneric with living European species, in the Eocene–Oligocene of the Pacific Coast, throws interesting light upon the former ranges of these genera, not to mention the evidence afforded of their considerable antiquity and the fixity of their characters.

[1] Proc. Malac. Soc. Lond., ix, pp. 126–45, 1910.

Genus Unio, Retzius.

Mya (sp.), Linné, 1758 (*M. pictorum*, L.); *Unio*, Retzius, 1788 (*M. pictorum*, L.); *Lymnium*, Oken, 1815 (*M. pictorum*, L.); *Unionea*, Rafinesque, 1815 (emended form); *Mysca*, Turton, 1822 (*M. pictorum*, L.).

Type, *Mya pictorum*, Linné.

Shell of moderate size, averaging 60 mm. in length, sub-solid, elongate-elliptical, anteriorly sub-truncate, somewhat pointed posteriorly, slightly indented in front of posterior terminus, umbones small, lying about one-third of distance from anterior end, rather low, and marked by a few doubly looped nodulous ridges, two lateral teeth, and one well-developed and one more or less obsolete pseudo-cardinal in left valve, one lateral and one pseudo-cardinal in right valve, pseudo-cardinals acicular, lying sub-parallel to hinge; habitat lacustro-fluviatile.

Unio transpacifica, Arnold & Hannibal, n.sp.[1] Pl. VII, Fig. 18.

Shell of moderately large size, varying from compressed to somewhat inflated, very similar to *U. pictorum*, but proportionately broader, particularly in the umbonal region, less distinctly truncate anteriorly, margin of shell slightly sinuate in front of posterior extremity, hinge heavier than in *pictorum*, a second pseudo-cardinal imperfectly developed in left valve; habitat apparently lacustrine.

Type: length 58, breadth 30, depth of valves 20 mm. Cotype (cut into exposing hinge in both valves): length 70, breadth 35, depth of valves 26 mm.

Eocene: local freshwater beds in Tejon formation of Washington and California.

Bluffs along Olequa Creek at shoals, one and a half miles above town (types); above shoals two miles above town; bend below railroad bridge, one-third mile below town, Little Falls, Washington (H. Hannibal).

One-fourth mile above Carnegie Pottery plant, in cutting along Western Pacific Railway, Corral Hollow, Tesla, California (Stanford University Geological Survey, per W. H. Ochsner) (H. Hannibal).

The first true American *Unio* known.

'*Unio*' *penultimus*, Gabb.

Pal. Cal., i, p. 182, pl. xxiv, fig. 164, 1864.

Eocene—Tejon formation: coal-mines near Mount Diablo, California.

Whatever may be said of this species, the supposed type of which, in a very fragmentary condition, is preserved in the Geological Museum at the University of California, it is not a Naiad at all. It bears more resemblance to an *Anomia* than any other genus which the writer could recall while examining it.

[1] The types of this species, of *Viviparus Washingtonianus* (*Pachychilus Drakei*), and of *Ambloxus Olequaensis* were obtained by the writer during the summer of 1911 while collecting marine Eocene fossils at Little Falls, Washington, in the interests of Dr. Ralph Arnold.

Genus Migranaja, n.gen.

Unio (sp.), Lamarck, 1801 (*Unio littoralis*, Lam.).

Type, *Unio littoralis*, Lamarck.

Shell of moderate size, averaging 50 mm. in length, sub-solid, ovate-elliptical, crassiform, rounded in front and behind, umbones broad, elevated, and marked by numerous rather fine wavy ridges, which extend out on later growth, grading into obsolete chevrons; two lateral and two pseudo-cardinal teeth in left valve and one each in right, the pseudo-cardinals clavate, stumpy, and lying obliquely transverse to hinge; habitat lacustro-fluviatile.

The present group, which does not seem to have been heretofore distinguished from *Unio*, but differs obviously in the form of the hinge-teeth and early growth of the shell, has a distribution, considering both fossil and recent records, from Eastern Oregon to Spain, equalled in the Naiades only by *Margaritana*, *Unio*, and *Anodonta*.

Migranaja Condoni (White).

Unio Condoni, White, 1885.

Shell large for genus, similar in outline to *littoralis*, but distinguishable by the broader, more inflated umbonal region; hinge essentially the same, but cardinal teeth heavier; habitat apparently lacustrine.

Oligocene: local freshwater beds in upper portion of John Day formation, Oregon.

Genus Anodonta, Lamarck.

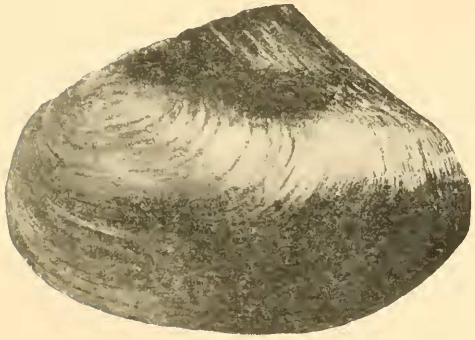
Mytilus (sp.), Linné, 1758 (*M. cygneus*, L.); *Anodontites* (sp.), Bruguière, 1792 (*M. cygneus*, L.); *Anodonta*, Lamarck, 1799 (*M. cygneus*, L.); *Anodon*, Oken, 1815 (emended form); *Anodontes*, Cuvier, 1817 (emended form); *Brachyanodon*,[1] Fischer & Crosse, 1893 (*A. coarctata*, Anton = *A. impura*, Say).

Type, *Mytilus cygneus*, Linné.

Shell of moderate size, averaging 50 mm. in length, anodontiform, thin, broadly ovate, ovate-elliptical, or elongate-elliptical, compressed or inflated, beaks barely elevated above general curvature of shell, and marked by low calycules and a varying number of fine wavy knotted ridges, hinge edentate and gently curved; adolescent growth broadly ovate, alate and compressed; habitat lacustrine and lacustro-fluviatile.

Anodontites of Bruguière has recently been revived for the present group without, in the writer's opinion, good cause. The name appears to have been originally intended for all the edentate Naiades of Europe and elsewhere. *Mytilus cygneus* and *anatinus* are mentioned, but the first species, and the only one described, is the South American *A. crispata*, a species of Hyriinæ. In 1799 Lamarck, doubtless aware of Bruguière's group, proposed *Anodonta* for the European species, thus incidentally restricting *Anodontites* to the single South

[1] With one or two others from the 'Mission Scientifique Mexique' omitted from the Zoological Record.



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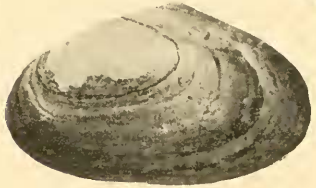

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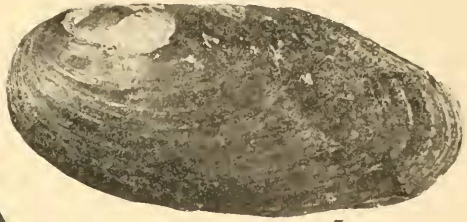

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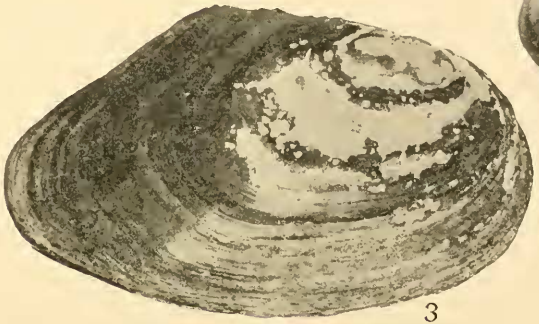

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7

SUBSPECIES OF ANODONTA CYGNEA FROM WESTERN NORTH AMERICA.

American species. Attempts a hundred years or more later to establish *cygnea* as the type of *Anodontites* are *post mortem*.

The Simpsonian *Anodonta* included a varied assortment of edentate Anodontinæ such as *imbecillis*, *grandis*, *marginata*, *dejecta*, and *suborbiculata*, derived without doubt from several none too closely related stocks possessing hinge-teeth. Since the resemblances are due chiefly to parallel modifications, these can hardly be regarded as congeneric with *A. cygnea*, which is the only true *Anodonta*, in America at least. The proper segregation of these species which lack the most important index to their relationships is hardly a simple problem. The anatomy, of prime import in the discrimination of more comprehensive groups, offers only partial aid, and other characters, such as the adolescent stages and beak sculpture, should enter into consideration. A too conservative use of the latter character cannot be recommended, however: the development of plications, pustules, etc., is subject to considerable individual and colonial variation in species which have not entirely passed beyond the sculptured stage, and it is reasonable to suppose that this variation remains latent, though the sculpturing is carried back to the earliest post-glochidial growth. Anyone may satisfy himself of the truth of this by examining a large series of *Anodonta cygnea* from random localities.

Anodonta cygnea (Linné). Pl. V, Figs. 3, 4, 8.

Mytilus cygneus, Linné, 1758; *M. anatinus*, Linné, 1758 (syntonic form); *A. Cellensis*, C. Pfeiffer, 1821; *A. ponderosa*, C. Pfeiffer, 1825 (syntonic form); *A. Oregonensis*, Lea, 1836; *Anodon cognata*, Gould, 1850; *A. Kennerlyi*, Lea, 1861.

Anodonta cygnea impura (Say). Pl. V, Figs. 1, 2, 7.

A. impura, Say, 1829; *A. Nuttalliana*, Lea, 1838; *A. Wahlamatensis*, Lea, 1838 (syntonic form); *A. coarctata*, Anton, 1839 (syntonic form); *A. Californiensis*, Lea, 1852; *A. triangularis*, Trask, 1855 (syntonic form); *A. rotundovata*, Trask, 1855 (syntonic form); *A. exilior*, Lea, 1871 (syntonic form); *A. Nuttalliana*, var. *Idahoensis*, Hemphill, 1891 (syntonic form); *A. Chapalensis*, Crosse & Fischer, 1892 (syntonic form); *A. Chalcoensis*, Crosse and Fischer, 1893 (syntonic form); *A.* (*Nuttalliana* var.?) *lignitica*, J. G. Cooper, 1894; *A. Kettlemanensis*, Arnold, 1910 (syntonic form).

Anodonta cygnea Beringiana (Middendorf). Pl. V, Figs. 5, 6.

A. Zellensis, var. *Beringiana*, Middendorf, 1851; *A. Youconensis*, Lea, 1867; *A. Youkanensis*, Lea, 1868.

Anodonta cygnea impura. Shell of moderate size, quadrate-discoidal, alate, decidedly broader posteriorly, rather compressed, early growth similar in outline to adult; habitat sluggish streams and lakes.

Western and mountainous portions of Mexican Province from the vicinity of Mexico City northward. Arizona, Los Angeles, Mojave, Colorado, Coast Range, Klamath, Nevada, Utah, and Columbia Systems, rarely farther north.

Quaternary: Bonneville Lake beds, Utah; Lahontan and Carson Prison Lake beds, Nevada; Owens and Le Conte Lake beds, California. Pliocene: Kettleman, Santa Clara, and Cache Lake beds, California. Miocene: Contra Costa Lake beds, California.

A. cygnea. Shell similar to preceding, usually somewhat larger, however, elongate-ovate, sub-alate, somewhat broader posteriorly, tapering to a blunt point, moderately inflated, growth to mid-adolescence as in *impura*; habitat similar.

Entire Palæarctic Region. Alaska, Fraser, Columbia, Klamath, Utah, and Nevada Systems, but occasionally farther to north or south. Quaternary: Bonneville Lake beds, Utah. Pliocene: Kettleman Lake beds, California; Idaho Lake beds, Idaho and Nevada.

A. cygnea Beringiana. Shell similar to preceding but attenuate-elliptical, not broader posteriorly, barely alate, strongly inflated; *impura* stage pushed back to early adolescence, *cygnea* stage to mid-adolescence; habitat same.

North-Eastern Siberia. Yukon, Alaska, Fraser, rarely in Columbia System.

The accompanying Plate V illustrates the evolution of this species from *impura* through *cygnea* to *Beringiana*. It seems probable that *impura* is of West American origin, and after giving rise to a northern sub-species, *cygnea*, the latter spread to Asia by a land-bridge during the upper Miocene at a time when the climate was somewhat warmer than at present, and *cygnea* doubtless occupied all Alaska. Once in Asia the extension of *cygnea* to Europe and the Mediterranean region has been only a matter of time and facility in taking advantage of stream-captures, etc. There appears to be no evidence that more than the one race is represented in the Old World outside of Kamchatka, though occasional atavistic individuals suggest *impura*, while others tend to acquire the characters of *Beringiana*. It seems improbable that the European Najadologists would overlook these well-marked sub-species if they existed, so thoroughly has this species been studied. *Anodonta cygnea Beringiana* appears to be a sub-species of comparatively late origin, arising in Alaska, doubtless, and taking advantage of the early Quaternary land-bridge to migrate to Siberia. Had it originated in Kamchatka or crossed the Bering Straits during the Miocene connexion it would be difficult to explain why it has not extended its range farther to the westward.

The problem of temperature appears to be an important factor in limiting the north and south distribution of the various sub-species. It is noteworthy that *cygnea* does not extend in the Old World beyond the latitudes of its extreme limits in the Californian Province.

The very young of this species have been frequently obtained in organic mud with *Corneocyclas pulchella*.

Genus Gonidea, Conrad.

Anodonta (sp.), Lea, 1838 (*A. angulata*, Lea); *Gonidea*, Conrad, 1857 (*A. Randalli*, Trask = *A. angulata*, Lea, first species).

Type, *Anodonta angulata*, Lea.


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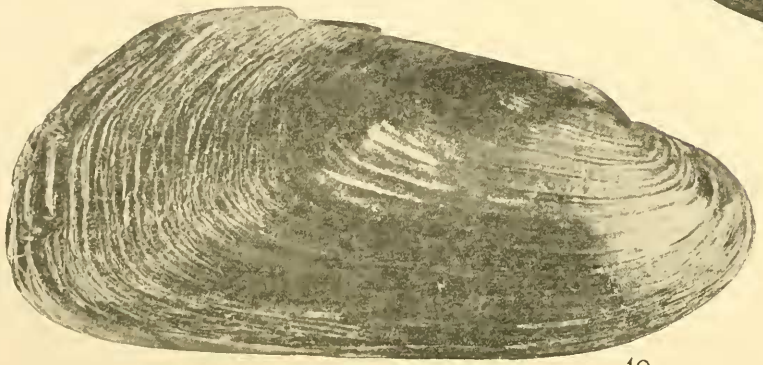
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14*b*


14*a*


13*b*


13*c*


13*a*

Sub-genus LIMNOBASILISSA, n.sub-gen.

Margaritana (sp.), J. G. Cooper, 1894 (*M. subangulata*, J. G. C.).

Type, *Margaritana subangulata*, J. G. Cooper.

Sub-genus *Limnobasilissa*. Shell of moderate size, averaging 60 mm. in length, margaritaniform, sub-solid, elongate-quadrate, rounded in front, obliquely truncate behind, postero-ventral margin barely acutely angular, posterior slope sub-rounded, beaks marked by several wavy ridges which make an abrupt bend on crossing the postero-ventral slope, early growth similar in outline to adult, hinge with a reduced clavate pseudo-cardinal in each valve, hinge-line sinuate in front of umbones; habitat lacustrine.

Sub-genus *Gonidea*, s.s. Shell of moderate size, similar to *Limnobasilissa*, but anodontiform, more or less elongate-trigonal and anteriorly pointed, posterior slope more or less carinate, hinge with an obsolete pseudo-cardinal in each valve or edentate, but slightly sinuate in front of umbones; *Limnobasilissa* stage carried back to early adolescence; habitat fluviatile.

GONIDEA (LIMNOBASILISSA) ANGULATA SUBANGULATA (J. G. Cooper).

Margaritana subangulata, J. G. Cooper, 1894; *G. Coalingensis*, Arnold, 1910 (syntonic form); *G. Coalingensis*, var. *Cooperi*, Arnold, 1910.

Shell of moderate size, elongate-quadrate, compressed, of about equal width posteriorly and anteriorly, rounded in front, rather squarely decurtate behind, postero-ventral slope barely angular; beaks low, hinge with a reduced pseudo-cardinal in each valve; habitat apparently lacustrine.

Pliocene: Kettleman, Santa Clara, and Cache Lake beds, California.

GONIDEA ANGULATA (Lea).

Anodonta angulata, Lea, 1838; *Anodon feminalis*, Gould, 1850; *A. Randalli*, Trask, 1855; *A. biangulata*, Sowerby, 1869.

GONIDEA ANGULATA HAROLDIANA, Dall. Pl. VI, Fig. 2.

Anodonta angulata, var. *subangulata*, Hemphill, 1891, not *Anodon(ta) subangulata*, Anthony, 1865; *G. angulata*, var. *Haroldiana*, Dall, 1908.

Shell of moderate size, elongate-quadrate, rather compressed, somewhat broader posteriorly, rather obliquely truncate behind, postero-ventral slope exhibiting a rudimentary carina, beaks barely elevated, hinge with a very obsolete pseudo-cardinal in each valve; early adolescent stage as in mature *subangulata*; habitat quiet rivers, creeks, and sloughs.

Fraser, Columbia, Klamath, Coast Range, and Los Angeles Systems.

G. angulata. Shell of moderate size, elongate-trigonal, strongly inflated in the region of the postero-ventral ridge, which is sharply carinate, giving the shell an appearance of being cut off abruptly behind, pointed anteriorly, broad and obliquely truncate posteriorly, beaks somewhat elevated, hinge edentate and but slightly sinuate; shell similar to *Haroldiana* at mid-adolescence, to *subangulata* in very young stages; habitat rivers and brisk streams.

Geographic distribution same as *Haroldiana*.

G. angulata, *angulata Haroldiana*, and *angulata subangulata* all occupy or occupied the same geographic range. *Angulata* is confined to rapid streams and rivers with considerable current; *Haroldiana* to sloughs, sluggish creeks, and slow-moving rivers; while *subangulata* was an abundant Naiad in the great lakes which existed on the Pacific Coast during the Pliocene period, a situation in which *angulata* is never and *Haroldiana* seldom found. This is an excellent instance of a change of station accompanying the evolution of the shell, and therefore of particular interest.

In attempting to classify this species genetically the writer has been in somewhat of a quandary. Either two comprehensive stages equivalent and analogous to sub-genera in all the other Unionidæ must be treated as one sub-genus (necessitating a definition sufficiently broad to cover half the family and several genera which have nothing to do with this series), or the species must be arbitrarily divided into two species simply because the extremes are sufficiently distinct, without regard for an unbroken chain of intermediate stages, or one sub-species must be placed in one sub-genus and two in the other. The last alternative has been followed, since it is most nearly in keeping with natural relationships in the Naiades, though the writer does not regard it as desirable from a classification standpoint. It is an unfortunate limitation of the Linnean System that no disposition was made in case intermediate forms have not died out, or died out but left fossil remains.

The young of this species have been found in deep quiet reaches of water burrowing into stiff mud or clay; juvenile *Haroldiana* occur in similar situations.

Gonidea Hemphilli, n.sp. Pl. VII, Fig. 19.

Shell reminding in a general way of *G. angulata Haroldiana*, but decidedly smaller, proportionally more elongate, the postero-ventral ridge less sharply defined and terminating in a rounded margin, shell not broader posteriorly, and less obliquely decurtate behind, hinge with a very rudimentary pseudo-cardinal in each valve; habitat apparently lacustrine.

Length 31, breadth 14, depth of valve 5 mm.

Miocene: Contra Costa Lake beds, California.

Water-tunnel, head of Telegraph Cañon, Berkeley Hills, California.

Named after Mr. Henry Hemphill, the veteran collector.

Genus Arnoldina, n.gen.

Anodonta (sp.), Lewis, 1875 (*A. dejecta*, Lewis).

Type, *Anodonta dejecta*, Lewis.

Shell of rather large size, averaging 80 mm. in length, anodontiform, sub-solid, elongate-elliptical, distinctly broader posteriorly, moderately inflated, beaks which are not elevated above general curvature of shell, marked by prominent calycules and a few coarse doubly looped ridges alternating with pits which lie along the postero-ventral ridge,

early growth elongate-ovate, hinge edentate and gently curved; habitat lacustro-fluviatile.

Arnoldina, named after Dr. Ralph Arnold, includes, so far as known, the sole species, *Anodonta dejecta*, Lewis, a mollusc which has proved an anomaly to everyone who has studied it. The development, peculiar beak-sculpture, and an indescribable velvety texture of the shell preclude its reference to *Anodonta* or any allied genus.

ARNOLDINA DEJECTA (Lewis). Pl. VI, Fig. 9.

Anodonta dejecta, Lewis, 1875, in Yarrow, 1875; *A. Mearnsiana*, Simpson, 1893.

Shell as in genus; inhabits ponds and sluggish streams.

Arizona System.

Quaternary: Le Conte Lake beds, California.

Superfamily CYRENOIDEÆ (Gray), 1840.

The Cyrenoideæ, as here understood, embrace three families—the Cyrenidæ, Gray, 1840 (Corbiculidæ, Gray, 1847), a comprehensive and probably not entirely homogeneous group of brackish-water bivalves, which does not concern this discussion particularly, the Sphæriidæ, Bourguignat, 1885 (Cycladæ, Fleming, 1828), and the Corneocycladidæ, nov. (Pisidiadæ, Gray, 1857), aquatic groups, both of which are represented west of the Rocky Mountains.

The simplest forms in each family have, or at one time had, rudimentary hinge-teeth, a quadrate-elliptical form, and low subcentral umbones. From this type there has been a general tendency to develop a moderately complex hinge, the teeth corresponding to the general formula — R. 101–0101–101, L. 010–1010–010[1] — followed ultimately by its degeneration, while a trigonal outline and high sub-terminal umbones are acquired. In the Cyrenidæ and Sphæriidæ the umbones migrate toward the anterior extremity, a modification analogous to that taking place in the Unionoideæ and various marine Pelecypoda, notably the Mytilidæ and their allies. In the Corneocycladidæ, however, the migration takes place toward the posterior end. The cause is not understood, but there is reason to suspect it to be produced in the same manner as the sinistral coiling of the Gastropoda—the positions taken by the various cells in the early cleavage stages of the developing embryo.

An interesting feature of the study of the Sphæriidæ and Corneocycladidæ, somewhat aside from the systematic phase, is the colour of the epidermis. Anyone, with the assistance of a few drops of oxalic acid, may convince himself that the shells of the members of these families are uniformly a pale-straw colour. Deposited in the epidermis, however, at the time of its formation, are generally varying amounts of iron salts which produce the grey, green, brown, and

[1] *Eupera*, a tropical genus, has but a single somewhat bifid cardinal in each valve in species seen by the writer, and the cardinals of the right valve of *Corneocyclas*, sub-gen. *Pisidium*, are commonly united above. On the other hand, the Amesodas show a tendency toward a bifurcation of the cardinals.

black colours, commonly described as specific characters. Not improbably this is a protective device on the part of the mollusc; the writer's experience would indicate that such is the case.

Family SPHÆRIIDÆ, Bourguignat, 1885.

Shell small, quadrate, ovate, or trigonal, inflated, concentrically striate, umbones sub-central or somewhat anterior, hinge more or less developed, cardinal teeth small and feeble, laterals short and weak, ligament deep-seated and inconspicuous, pallial line simple; animal hermaphroditic, viviparous; habitat fluviatile and lacustrine.

Sphærium and *Musculium* represent this family in the Nearctic Region. The species are characteristically widespread; none of the recent Californian forms are confined west of the Rocky Mountains, and at least three are common to the Palæarctic Region.

Genus Sphærium, Scopoli.

Tellina (sp.), Linné, 1758 (*T. cornea*, L.); *Sphærium*, Scopoli, 1777 (*T. cornea*, L.); *Cyclas* (sp.), Bruguière, 1798, Lamarck, 1799 (*T. cornea*, L.), not as restricted by Link, 1807, and Dall, 1903; *Cornea*, Megerle, 1811 (*C. communis*, Meg. = *T. cornea*, L.); *Cycladea*, Rafinesque, 1815 (emended form of *Cyclas*); *Cycladites*, Krüger, 1848; *Corneola*, Clessin in Westerlund, 1890 (*T. cornea*, L.), not *Corneola*, Held, 1837.

Type, *Tellina cornea*, Linné.

Sub-genus Amesoda (Rafinesque).

Amesoda, Rafinesque, 1820 (*Cyclas similis*, Say); *Pisum*, Bourguignat, 1857 (*Cyclas rivicola*, Leach), not *Pisum*, Megerle, 1811; *Sphæriastrum*, Bourguignat, 1854 (*Cyclas rivicola*, Leach); *Cyrenastrum*, Bourguignat, 1854 (*Cyclas solida*, Normand).

Type, *Cyclas similis*, Say.

Sub-genus *Sphærium*, s.s. Shell of small size, averaging 10 mm. in length, sub-solid, quadrate-discoidal, finely striate, beaks low, hinge-teeth small, poorly developed, cardinals oblique to hinge, laterals rather short; habitat lacustrine and fluviatile.

Sub-genus *Amesoda*. Shell similar to preceding, but usually larger (averaging 15 mm. in length), and more solidly built, trigonal or quadrate-trigonal in outline, completely coarsely striate, beaks elevated, hinge heavier and better developed, one of the cardinals commonly bifid; *Sphærium* stage passed during early adolescence; habitat similar to *Sphærium*.

Sphærium corneum (Linné).

Tellina cornea, Linné, 1758; *Cyclas rhomboidea*, Say, 1822.

Shell of moderate size, quadrate or quadrate-elliptical, moderately or strongly inflated; habitat lakes and quiet streams.

Boreal portions of Palæarctic and Nearctic Regions. Yukon, Fraser, and Columbia Systems.

Quaternary: Loess of eastern States.

Sphærium tenue (Prime).

Cyclas tenuis, Prime, 1851; *Sphærium occidentale*, Prime, 1860; *S. Uintaense*, Call, 1886; *S. Walkeri*, Sterki, 1901.

Shell small, quadrate-discoidal, moderately compressed; habitat lakes and marshes.

Boreal portions of Nearctic Region. Yukon, Columbia, and Utah Systems.

Quaternary: Loess of eastern States.

Sphærium patellum (Gould).

Cyclas patella, Gould, 1850; *C. fabale*, Prime, 1851; *Sphærium Primeanum*, Clessin, 1878.

Shell of moderate size, quadrate-elliptical, somewhat compressed; habitat marshy lakes and streams.

Boreal portions of Nearctic Region. Fraser and Columbia Systems.

Sphærium (Amesoda) simile (Say).

Cyclas similis, Say, 1817; *C. striatina*, Lamarck, 1818; *C. staminea*, Conrad, 1834; *C. dentata*, Haldeman, 1841; *C. aurea*, Prime, 1851; *C. solidula*, Prime, 1851; *C. nobilis*, Gould, 1855; *Sphærium Vermontanum*, Prime, 1861; *C. tumidum*, Baird, 1863; *S. 'sulcatum*, Lam.', Keep, 1888; *S. Hendersoni*, Sterki, 1906; *S. Pilsbryanum*, Sterki, 1909; *S. Kettlemanensis*, Arnold, 1910; *S. Cooperi*, Arnold, 1910; not *S. 'simile*, Say', F. C. Baker, 1898 = *S. sulcatum*, Lam.

Shell of moderate or large size, quadrate-trigonal, varying from moderately compressed to inflated, rather finely or coarsely striate; habitat lakes, marshes, and streams.

Nearctic Region. Fraser, Columbia, Klamath, Utah, Nevada, Colorado, Arizona, and Coast Range Systems.

Quaternary: Loess of eastern States; Bonneville Lake beds, Utah; Lahontan Lake beds, Nevada. Pliocene: Santa Clara, Cache, and Kettleman Lake beds, California.

Sphærium (Amesoda) Idahoense (Meek).

Sphærium (?) *Idahoensis*, Meek, 1870; *S. rugosum*, Meek, 1870 (fig. of type only = juv. individual).

Shell very large, quadrate-trigonal, inflated, coarsely sparsely striate; habitat apparently lacustrine.

Eocene: Truckee Lake beds, Nevada; Payette Lake beds, Idaho.

Sphærium (Amesoda) Rogersi, n.sp. Pl. VII, Fig. 21.

Shell large, elongate-trigonal, moderately inflated, coarsely striate; habitat apparently lacustrine.

Length 20, breadth 14·5, depth of valves 9·5 mm.

Eocene: local freshwater beds in Tejon formation, California.

One-fourth mile above Carnegie Pottery plant, in cutting along Western Pacific Railway, Corral Hollow, Tesla, California (Stanford University Geological Survey, per W. H. Ochsner) (H. Hannibal).

More elongate, more compressed, and more coarsely striate than *S. sulcatum*, which it most resembles. Named after Dr. A. F. Rogers, chief of the Stanford University party who discovered the freshwater deposits in the Eocene of Corral Hollow.

Sphærium (Amesoda) Catherinæ, n.sp. Pl. VII, Fig. 20.

Shell small, striate, elongate-arcæform, umbones high, nearly medial, hinge-line rather straight, anterior and posterior margins rounded; habitat apparently lacustrine.

Length 5, breadth 3·8, depth of valves 4 mm.

Eocene: Truckee Lake beds, Nevada.

Hill near Hawthorne on the Belmont stage-road, Nevada.

There is some doubt whether this species is really a *Sphærium*; the arcæform shape is peculiar. Named after Mrs. Catherine Stevens, of San Diego.

Sphærium (Amesoda) Andersonianum, n.sp. Pl. VI, Fig. 11.

Shell very large, comparing in size with *S.* (*A.*) *rivicola* of Europe, but proportionally less inflated, less elongate, and trigonal-quadrate rather than trigonal-ovate, striate, beaks high; habitat apparently lacustrine.

Length 17·5, breadth 15, depth of valve 4 mm.

Pliocene: Idaho Lake beds, Idaho and Oregon.

Badland Hills, one mile east of Sand Hollow, Oregon (type) (R. B. Moran); near Baker City, Oregon (F. M. Anderson, per I. B. Sturges); Oil City, Idaho (E. L. Ickes).

Named after Mr. F. M. Anderson, of the California Academy of Science, who has kindly loaned the writer some interesting material from the Pliocene lake deposits of Eastern Oregon.

Not subsequently recognized:

Sphærium Spokani, Baird, 1863.

Spokane and Kootenai Rivers, British Columbia.

Sphærium Californicum, Clessin, 1878.

California.

Genus Musculium, Link.

Tellina (sp.), Müller, 1774 (*T. lacustris*, Müll.); *Cyclas* (sp.), Draparnaud, 1805 (*C. caliculata*, Drap. = *T. lacustris*, Müll.); *Musculium*, Link, 1807 (*T. lacustris*, Müll.); *Calyculina*, Clessin, 1872 (*C. caliculata*, Drap. = *T. lacustris*, Müll.); *Primella*, J. G. Cooper, 1890 (*Sphærium* (*Primella*) *Raymondi*, J. G. C. = *T. lacustris*, Müll.).

Type, *Tellina lacustris*, Müller.

Shell of moderate size, averaging 10 mm. in length, fragile, quadrate, quadrate-ovate, or quadrate-trigonal, finely concentrically and radially striate, umbones elevated and usually caliculate, sub-central or slightly anterior, hinge rudimentary, the teeth minute, cardinals frequently undeveloped or when developed those in right valve not separated above; habitat lacustrine.

For a genus possessing such a fragile shell it is remarkable that *Musculium* should occur frequently as a fossil. It might be noted that *Sphærium Florissantense*, Ckll., of the Oligocene of Colorado, groups here.

Musculium lacustre (Müller).

Tellina lacustris, Müller, 1774; *Cyclas Ryckholti*, Normand, 1841; *C. truncata*, Linsley, 1848; *C. cardissa*, Prime, 1851; *C. rosacea*, Prime, 1851; *C. securis*, Prime, 1851; *C. sphærica*, Anthony, 1852; *Sphærium lenticula*, 'Gould,' Prime, 1862; ? *S. Cooperianum*, Prime, 1869 (nude name); *S.* (*Primella*) *Raymondi*, J. G. Cooper, 1890.

Shell of small or moderate size, quadrate-trigonal, inflated in umbonal region, beaks high; habitat lakes and marshes.

Palæarctic and Nearctic Regions. Fraser, Columbia, Klamath, Coast Range, and Mojave Systems.

Quaternary: Loess of eastern States; post-Glacial deposits of Vancouver Island.

Musculium ovale (Férussac).

Cyclas ovalis, Férussac, 1807; *C. transversa*, Say, 1829.

Shell large, elongate-quadrate, somewhat compressed, but varying in this respect, umbones high; habitat lakes and marshes.

European and American Provinces, possibly extending into Colorado System.

Musculium partumeium (Say).

Cyclas partumeia, Say, 1822; *C. elevata*, Haldeman, 1841; *C. Jayensis*, Prime, 1851; *Sphærium* '*patella*, Gould', Keep, 1888.

Shell large, quadrate-ovate, moderately or but slightly inflated, umbones low; habitat lakes and marshes.

Nearctic Region. Klamath and Coast Range Systems.

Quaternary: Loess of eastern States. Miocene: Contra Costa Lake beds, California.

Family CORNEOCYCLADIDÆ, n.fam.

Shell small or minute, sub-solid, ovate or trigonal, compressed or inflated, finely concentrically striate, umbones posterior or posteriorly sub-terminal, hinge well developed or more or less obsolete, ligament deep-seated and inconspicuous, pallial line simple; animal hermaphroditic, viviparous; habitat lakes, marshes, streams, and springs, less frequently in moist situations.

The Californian Corneocycladidæ belong exclusively to the type and principal group *Corneocyclas*. *Corneocyclas* is, however, not coextensive with the old genus *Pisidium*; *Tellina Henslowiana*, Sheppard, of Europe and the eastern States, and *Pisidium cruciatum* of Sterki (American Province) belong to *Tropidocyclas*, a group whose species indicate a radially sculptured stage now outgrown in their phylogenetic histories.

Many of the members of this family are of widespread occurrence. As frequently happens with microscopic species distributed over

considerable areas, there has been a rather unnecessary duplication of specific names and consequently much confusion of the literature. The revision of the Nearctic species has not been difficult since cotypes, locotypes, or named specimens (chiefly examined by the late E. W. Roper) of nearly all have been at hand, but the European species constitute a problem which the writer feels neither the inclination or capability of undertaking; hence the synonymy of *Corneocyclas pulchella*, which extends to the Old World, is another story. It is probable that when the Palæarctic forms are thoroughly worked up they will be found to be comparatively few in number, as is true of the North American species. One of the chief stumbling-blocks in classification seems to be the colour of the epidermis. Since this is known to be not of hereditary consequence, and the grouping of the species offers no particular difficulties, the elucidation of the specific synonymy becomes a comparatively simple problem.

Genus Corneocyclas, Férussac.[1]

Tellina (sp.), Gmelin, 1788 (*T. pusilla*, Gmel.); *Cyclas* (sp.), Say, 1817 (*C. dubia*, Say = *T. Virginica*, Gmel.); *Corneocyclas* (*pars*), Férussac, 1818 (*T. pusilla*, Gmel.); *Phymesoda*, Rafinesque, 1820 (*C. dubia*, Say = *T. Virginica*, Gmel.); *Galileja*, Costa, 1839 (*G. tenebrosa*, Costa = *Pisidium pulchellum*, Jenyns); *Euglesia*, 'Leach MS.,' Gray, 1840 (*E. Henslowiana*, 'Leach MS.' (not *T. Henslowiana*, Shepp.) = *T. pusilla*, Gmel.), in synonymy; *Euglesa*, Leach, 1852 (*T. pusilla*, Gmel.); *Cycladina*, Clessin, 1871 (*T. pusilla*, Gmel.); *Cymatocyclas*, Dall, 1903 (*Pisidium compressum*, Prime).

Type, *Tellina pusilla*, Gmelin.

Sub-genus Pisidium (Pfeiffer).

Cardium (sp.), Montagu, 1803 (*Tellina amnica*, Müll.); *Pisidium*, Pfeiffer, 1821 (*P. obliquum*, Pfr. = *T. amnica*, Müll.); *Pera*, 'Leach MS.,' Gray, 1840 (*P. fluviatilis*, Leach MS. = *T. amnica*,

[1] Dall, Trans. Wagn. Inst., iii (4), p. 1460, 1903, has shown that *Corneocyclas*, originally based on an assemblage of Cyrenoideæ, from which *Tellina pusilla*, Gmel., was selected as type, in a restricted sense takes priority over the more familiar name of this group, *Pisidium* of Pfeiffer. *Corneocyclas* has been generally regarded as a synonym of *Sphærium*, hence there have been objections to the use of the name in this novel connexion. The problem resolves itself into choosing the lesser of two evils. *Pisidium* cannot be retained as the genus in any event on account of the prior *Phymesoda* of Rafinesque. Anyone floundering through the maze of spelling and names in the *Monographie* in an attempt to determine what Rafinesque really intended to designate his genus and the species described under it (to say nothing of identifying the former except for the citation of *Cyclas dubia*, Say), would welcome *Corneocyclas* as a straw to a drowning man. Since Dall appears to be the first writer to establish a type for Férussac's group, and the one selected was not excluded from consideration, it does not seem necessary to question why this particular species should have been cited. Already *Corneocyclas* has found a place in the literature of the American and Australian freshwater Cyrenoids, and, if for no other reason, should not be disregarded without good reason.

Müll.), in synonymy; *Pisum*, Gray, 1847 (*T. amnica*, Müll.), not *Pisum*, Megerle, 1811; *Cordula*, Leach, 1852 (*T. amnica*, Müll.); '*Musculium*, Link,' H. & A. Adams, 1857 (*T. amnica*, Müll.); *Fluminina*, Clessin, 1873 (*T. amnica*, Müll.).

Type, *Tellina amnica*, Müller.

Sub-genus *Pisidium*. Shell small or minute, ovate, rather compressed, umbones low, somewhat posterior and naked, hinge well developed, cardinal teeth small and usually joined above in right valve, the anterior transverse, the posterior sub-parallel to hinge, laterals short and weak; habitat chiefly in rivers.

Sub-genus *Corneocyclas*, s.s. Shell similar to preceding but trigonal, umbones elevated, posteriorly sub-terminal, hinge rather poorly developed, teeth sub-obsolete; *Pisidium* stage usually completed in or shortly after leaving the marsupium (species which pass the *Pisidium* stage in the marsupium are frequently caliculate, due to the abrupt change in mode of growth); habitat lakes and springs, uncommonly in streams.

Corneocyclas (Pisidium) pulchella abdita (Haldeman).

Pisidium abditum, Haldeman, 1841; *P. ultramontanum*, Prime, 1865; *P. Angelicum*, Rowell, 1865; *P. nivale*, Westerlund, 1885; *P. Randolphi*, Roper, 1895; *P. Rowelli*, Sterki, 1903; *P. abditum Huachucanum*, Pilsbry & Ferriss, 1906.

Shell of moderate size, rather narrowly ovate and pointed anteriorly, compressed, beaks inconspicuous, hinge moderately developed; habitat streams, forms intergrading toward *pulchella* in lakes and springs.

Palæarctic and Nearctic Regions, Mexican Province.

Quaternary: Loess of eastern States; Summer Lake beds, Oregon.

Intergrading forms between this sub-species and *pulchella* are abundant and often hard to place.

Corneocyclas (Pisidium) Meeki, n.sp. Pl. VI, Fig. 12.

? *Sphærium rugosum*, Meek, 1877 (*pars*).

Shell large, broadly quadrate-ovate, moderately compressed, beaks low, hinge well developed; habitat apparently lacustrine.

Length 11, breadth 11, depth of valve 3 mm.

Eocene: Truckee Lake beds, Nevada; Payette Lake beds, Idaho.

Hill near Hawthorne on the Belmont stage-road, Nevada.

A large species recalling *C.* (*P.*) *amnica*, but broader, more convex, and rather quadrate in outline.

Not recognized by subsequent writers:

Pisidium Sibericum, Clessin, 1870.

Siberia; Port Clarence, Alaska.

Pisidium borealis, Clessin in Westerlund, 1890.

Siberia; Port Clarence, Alaska.

Corneocyclas Virginica (Gmelin).

Tellina Virginica, Gmelin, 1788; *Cyclas dubia*, Say, 1817.

Shell large, broadly trigonal-ovate, moderately inflated, umbones conspicuous and decidedly anterior, hinge fairly developed; habitat lakes and streams.

Boreal portions of American Province. Yukon System.

Quaternary: Loess of eastern States; Yukon Valley, Alaska.

A species more or less intermediate in character between *Pisidium* and *Corneocyclas*, but grouping best with the latter.

Corneocyclas pulchella (Jenyns).

Pisidium pulchellum, Jenyns, 1832; *P. variabile*, Prime, 1851; *P. Adamsi*, Prime, 1851; *P. ferrugineum*, Prime, 1851; *P. novaeboracense*, Prime, 1853; *P. occidentale*, Newcomb, 1863; *P. insigne*, Gabb, 1868; *P. Harfordianum*, Prime, 1869 (nude name), *fide* cotypes; *P. arcticum*, Westerlund, 1885; *P. glaciale*, Westerlund, 1885; *P. scutellatum*, Sterki, 1890; *P. Roperi*, Sterki, 1898; *P. Ashmuni*, Sterki, 1903; *P. proximum*, Sterki, 1906; *P. Californicum*, 'Newcomb MS.,' Berry, 1908 (nude name), *fide* locotypes; *P. Marci*, Sterki, 1909.

Shell of moderate size, prevailing smaller than sub-sp. *abdita* apparently, sub-trigonal, inflated, beaks prominent and sub-terminal, hinge not well developed, teeth sub-obsolete; habitat springs, marshes, lakes, and moist places, infrequently in streams intergrading with *abdita*.

Distribution apparently same as *abdita*.

Quaternary: Loess of eastern States; post-Glacial deposits of Vancouver Island; Summer Lake beds, Oregon; Owens Lake beds, California. Pliocene: Cache Lake beds, California.

The specific and varietal names adopted for this *Corneocyclas* and its sub-species are probably not the earliest, but they are the earliest which the writer with the literature and material at hand has been able to satisfy himself were actually applied to it.

Corneocyclas compressa (Prime).

Pisidium compressum, Prime, 1851.

Shell of small size, distinctly trigonal, inflated, beaks narrow and high, sub-terminal, hinge moderately developed; habitat lacustrine.

Nearctic Region. Yukon, Fraser, Columbia, Nevada, Klamath, Coast Range, Arizona, and Los Angeles (locally) Systems.

Quaternary: Loess of eastern States; Lahontan Lake beds, Nevada. Pliocene: Kettleman, Santa Clara, and Cache Lake beds, California. Miocene: Contra Costa Lake beds, California.

Corneocyclas rotundata (Prime).

Pisidium rotundatum, Prime, 1851.

Shell minute, ovate-trigonal, strongly inflated, beaks broad, elevated, and decidedly anterior, hinge much reduced; habitat lacustrine.

Boreal portions of American Province. Yukon System.

Corneocyclas æquilateralis (Prime).

Pisidium æquilaterale, Prime, 1852.

Shell of moderate size, inflated, beaks narrow, anterior, and somewhat elevated, hinge moderately developed; habitat chiefly lakes.

American Province, Siberia. Yukon System.

Quaternary: Loess of Kotzebue Sound, Alaska.

Corneocyclas Idahoensis (Roper).

Pisidium Idahoensis, Roper, 1896.

Shell of very large size, ovate-trigonal, strongly inflated, beaks broad, elevated, and decidedly anterior, teeth sub-obsolete; habitat lakes.

Boreal portions of American Province. Yukon, Fraser, and Columbia Systems.

Corneocyclas Tremperi, n.sp. Pl. VII, Fig. 22.

Shell minute, globular-trigonal, beaks anterior, broad, and somewhat elevated, hinge much reduced; habitat marshy lakes. Length 1·4, altitude 1·3 mm.; depth of valves 1 mm.

Mojave System.

Bluff Lake Cienaga, San Bernardino Mountains, California (H. Hannibal).

Named after Dr. R. H. Tremper, the first conchologist to visit this portion of the San Bernardino Mountains.

GASTROPODA.

Superfamily LYMNOIDEÆ (Broderip), 1839.

The Lymnoideæ, which embrace the purely aquatic inoperculate pulmonates of the North Temperate regions and the bulk of those inhabiting the more tropical portions of the world, include a number of families, all simple types, but differing fundamentally in the manner of whorling and ontogenetic stages. And the anatomy, of which much has been written, but little is actually known that will assist in explaining the internal modifications each group has undergone, appears to have specialized along dissimilar lines. There are excellent reasons for believing that these groups, like less bizarre types in general, are of considerable antiquity. The Planorbidæ had already reached their present specialization at the dawn of the Cenozoic, while a *Physa*, *P. prisca*, Walcott, was described several years ago from the Carboniferous of Nevada, a discovery which carries this genus back to rank as one of the oldest known freshwater molluses.

Family LYMNÆIDÆ, Broderip, 1839 (emended).

Shell of small or moderate size, dextral or sinistral, spire elevated, whorls varying from appressed to inflated, imperforate to umbilicate, columellar axis varying in different sub-families, aperture ranging from succiniform to auriculiform; animal dextral, hermaphroditic,

buccal plate with accessory lateral jaws, tentacles flat and triangular, foot quadrate; habitat aquatic or amphibious.

There are three sub-families as follows:—

Sub-family ACELLINÆ, n.sub-fam.

Whorls appressed, columellar axis imperforate and twisted, produced by a simple oblique reflection of the inner lip, aperture succiniform; habitat deep waters of lakes.

Genus, *Acella*.[1]

Sub-family LYMNÆINÆ, s.s.

Whorls somewhat inflated, columellar axis sub-perforate and twisted, with a more or less distinct marginal fold, aperture sub-auriculiform; habitat lakes and streams, generally in shallow waters.

Genus, *Lymnæa*, s.s.

Sub-family . . . . . .

Whorls inflated, columellar axis straight and umbilicate, the marginal fold obsolete, umbilicus partially hidden by a wide, smooth, vertical expansion of the inner lip, aperture auriculiform; habitat, young stages passed in water, adults more or less amphibious in habits.

Genus, *Lymnæa*; sub-genus, *Galba*.

As with other groups treated in these pages, the old genus *Lymnæa* (frequently spelt *Limnæa*) has undergone various vicissitudes during the last generation, and several classifications have been proposed, of which that of Dall in 1905 is perhaps the best, though unnecessarily elaborate for practical purposes. The North American species, which number about a dozen, may be segregated into *Acella*, Haldeman, a strictly American Province group, and a very primitive one based on a single species, *Lymnæa*, s.s., which includes the larger species of aquatic habits with a gyrate pillar, and *Lymnæa*, sub-genus *Galba*, which embraces the smaller amphibious species with a reflected pillar. Other groups have recently been given generic rank, but space is too valuable to devote to their discussion; the new ones proposed will be found in their proper places in the succeeding synonymy.

Lymnæa, s.s., and *Galba* are circumboreal, and occur extensively in the fossil state. *Lymnæa* ranges from the Mesozoic to the present, while *Galba* is first known from the older Tertiary. *Pleurolimnea*, Meek, based on a Laramie and Eocene fossil, *L. tenuicosta*, M. & H., from the Rocky Mountain region, has gone the rounds of the literature unquestioned as a member of this family. Its striking resemblance to *Zaptychius*, Walcott, of the Nevada Carboniferous, and *Tortacella*, White, of the Utah Cretaceous, which together form a peculiar group of Auriculoid pulmonates, apparently extinct, suggests that its columellar characters should be carefully examined with a view of redetermining its family position.

[1] *Acella* is included here merely to give an understanding of the classification. No attempt is made to give a complete list of the exotic genera of the various sub-families.

Genus Lymnæa, Lamarck.

Helix (sp.), Linné, 1758 (*H. stagnalis*, L.); *Lymnæa*, Lamarck, 1799 (*H. stagnalis*, L.); *Limneus*, Draparnaud, 1801 (emended form); *Lymnus*, Montfort, 1810 (emended form); *Radix*, Montfort, 1810 (*H. auricularia*, L.); *Limnæa*, Desmarest, 1812 (emended form), *non* Poli, 1795, polynomial; *Lymneus*, Braird, 1815 (emended form); *Lymnæus*, Cuvier, 1817 (emended form); *Lymnula*, Rafinesque, 1819 (emended form); *Auricularia*, Fabricius, 1823 (nude name); *Lymnea*, Risso, 1826 (emended form), not *Lymnea*, Rafinesque, 1815; *Limnea*, Fleming, 1828 (emended form); *Stagnicola*, 'Leach MS.,' Jeffreys, 1830 (*S. communis*, Leach MS. = *Buccinum palustre*, Müll.), in synonymy; *Gulnaria*, 'Leach MS.,' Turton, 1831 (*H. auricularia*, L.), in synonymy; *Leachia*, Jeffreys, 1833 (*H. stagnalis*, L.), not *Leachia*, Lesueur, 1821, nor Risso, 1829; *Limnophysa*, Fitzinger, 1833 (*B. palustre*, Müll.); *Bulimnea*, Haldeman, 1841 (*L. megasoma*, Say); *Neritostoma*, 'Klein,' H. & A. Adams, 1855 (*H. auricularia*, L.); *Auricula*, 'Klein,' H. & A. Adams, 1858 (*H. stagnalis*, L.); *Eulimneus*, Sandberger, 1875 (*H. stagnalis*, L.); *Polyrhytis*, Meek, 1876 (*Limnæa Kingi*, Meek = *H. Auricularia*, L.); *Pseudosuccinea*, F. C. Baker, 1908 (*L. columella*, Say).

Type, *Helix stagnalis*, Linné.

Sub-genus Galba (Shrank).

Buccinum (sp.), Müller, 1773 (*B. truncatulum*, Müll.); *Galba*, Shrank, 1808 (*B. truncatulum*, Müll.); *Leptolimnea*, Swainson, 1840 (*Limneus elongatus*, Drap. = *Buccinum glabrum*, Müll.); *Leptolimnæus*, Sandberger, 1875 (emended form); *Fossaria*, Westerlund, 1885 (*B. truncatulum*, Müll.); *Simpsonia*, F. C. Baker, 1911 (*L. humilis*, Say = *B. truncatulum*, Müll.).

Type, *Buccinum truncatulum*, Müller.

Sub-genus *Lymnæa*, s.s. Shell of moderate size, averaging 25 mm. in altitude, dextral, whorls normally sub-appressed or moderately inflated, sub-perforate, aperture succiniform or sub-auriculiform, axis simply reflexed in adolescent stage, with a rudimentary, well-developed, or sub-obsolete marginal fold in adult; habitat aquatic, chiefly in shallower portions of lakes and in sluggish streams, but not entirely confined to such situations.

Sub-genus *Galba*. Shell similar to preceding, but small, averaging 10 mm. in altitude, umbilicate, whorls usually well inflated, axis simply reflexed in early adolescence, with a gyrate marginal fold in later development (*Lymnæa* stage), adult with a smooth vertical expansion of the inner lip reflected over the umbilicus; habitat, the young in aquatic situations, the adults in springs, or more generally in moist places with *Succinea*, particularly on tangles of algæ.

The Lymnæas are characteristically of widespread occurrence. Of the species found west of the Rocky Mountains, four, *L. stagnalis*, *L. palustris*, *L. auricularia*, and *L.* (*Galba*) *truncatula*, are circumboreal, all of the remainder, except the newly characterized *L. Cooperi*, occur

in the American Province, while of the species in the latter region but four are absent from the area under consideration. This extent of distribution is without doubt dependent upon the adaptability of the species to a variety of surroundings. *L. Cooperi* and *L. truncatula* may be noted as examples; the former is practically confined to mountain streams, and unknown except in the Coast Ranges and adjacent valleys between San Francisco and Point Conception, California. *L. truncatula*, on the other hand, occurs in a wide variety of situations, marshy borders of lakes, moist banks of streams, and even such artificial situations as greenhouses; it is unquestionably the most extensively distributed member of the family.

Owing to the chaotic condition of the species of this genus in recent literature, it has been considered wise to include a brief account of each of the valid recent American Province forms. Only a few more prominent synonyms are mentioned, and no attempt is made to note the numerous mistaken identifications resulting from certain 'New School' writers using utterly worthless characters in specific discrimination. In case of doubt Binney's *Land and Fresh-water Shells of North America* may usually be taken as a guide in determining the particular species the writer refers to.

Lymnæa stagnalis (Linné).

Helix stagnalis, Linné, 1758; *Lymneus appressus*, Say, 1821; *Limnæus speciosus*, Ziegler in Rossmässler, 1835; *Limnæa 'jugularis*, Say', Haldeman, 1841; *L. lepida*, Gould, 1847 (juvenile); *L. stagnalis*, var. *occidentalis*, Hemphill, 1890 (syntonic form); *L. stagnalis Sanctæmariæ*, Walker, 1892 (syntonic form); *L. stagnalis*, var. *Higleyi*, F. C. Baker, 1905 (syntonic form); *L. stagnalis*, var. *perampla*, Walker, 1908 (syntonic form); *L. stagnalis Lillianæ*, F. C. Baker, 1910; *L. stagnalis Wasatchensis*, 'Hemphill MS.,' F. C. Baker, 1911.

Shell large, spire acuminate, whorls but slightly inflated, imperforate, aperture sub-succiniform, columellar fold pronounced; habitat lakes and marshes.

Boreal and Arctic portions of Palæarctic and Nearctic Regions. Yukon, Alaska, Fraser, Columbia, Utah, Colorado (locally), Nevada, Klamath, and Coast Range (locally) Systems.

Quaternary: Loess of eastern States; Lahontan Lake beds, Nevada; Bonneville Lake beds, Utah; post-Glacial deposits of Vancouver Island.

Lymnæa auricularia (Linné).

Helix auricularia, Linné, 1758 (syntonic form); *Buccinum peregrum*, Müller, 1774; *Lymnæa catascopium*, Say, 1817; *Lymneus emarginatus*, Say, 1821 (syntonic form); *L. pinguis*, Say, 1825 (syntonic form); *Limnæa pallida*, Adams, 1840; *L. decollata*, Mighels, 1841 syntonic form); *L. ampla*, Mighels, 1843 (syntonic form), not *Gulnaria ampla*, Hartm., likewise = *auricularia*, L.; *Limnæus Ontariensis*, 'Muhlfeldt MS.,' Küster in Chemnitz, 1862 (syntonic form); *Limnæa Sumassi*, Baird, 1863 (*partim*, front view);

L. Mighelsi, Binney, 1865; *L. Binneyi*, Tryon, 1865; *L. angulata*, Sowerby, 1872 (syntonic form); *L. Canadensis*, Sowerby, 1872; *L. (Polyrhytis) Kingi*, Meek, 1877 (syntonic form);[1] *L. scalaris*, Westerlund, 1883 (syntonic form); *Limnophysa Bonnevillensis*, Call, 1884 (syntonic form); *Radix ampla*, var. *Utahensis*, Call, 1884 (syntonic form); *Limnæa ovata*, var. *Atkaensis*, Dall, 1884 (nude name); *Limnæus Atkinensis*, 'Dall,' Clessin, 1886 (syntonic form); *Limnæa Woodruffi*, F. C. Baker, 1901; *L. emarginata*, var. *montana*, Elrod, 1902 (syntonic form); *L. Randolphi*, F. C. Baker, 1904 (syntonic form); *L. decollata Onorocnsis*, F. C. Baker, 1904 (syntonic form); *L. (Binneyi*, var. ?) *Preblei*, Dall, 1905 (syntonic form); *L. Petersi*, Dall, 1905 (syntonic form); *L. Nasoni*, F. C. Baker, 1906 (syntonic form); *L. Hinkleyi*, F. C. Baker, 1906 (syntonic form); *L. Jacksonensis*, F. C. Baker, 1907 (syntonic form); *L. pseudopinguis*, F. C. Baker, 1907 (syntonic form); *L. Davisi*, Walker, 1908 (syntonic form); *L. Pilsbryana*, Walker, 1909 (syntonic form); *L. emarginata Wisconsinensis*, F. C. Baker, 1910 (syntonic form); *Galba catascopium Adamsi*, F. C. Baker, 1911; *G. Alaskensis*, F. C. Baker, 1911 (syntonic form); *G. catascopium Niagraensis*, F. C. Baker, 1911; *G.* '*apicina*, Lea', F. C. Baker, 1911; *G.* '*apicina solida*, Lea', F. C. Baker, 1911.

Shell normally[2] of moderate size, spire broadly elevated, whorls moderately inflated, sub-perforate, aperture auriculiform, columellar fold inclined to partial obsolescence; habitat lakes and sluggish streams.

Boreal portions of Palæarctic and Nearctic Regions. Yukon, Alaska, Fraser, Columbia (locally—headwaters adjacent to upper Missouri Basin only), and Utah Systems.

Quaternary: Loess of eastern States; Bonneville Lake beds, Utah.

Lymnæa palustris (Müller).

Buccinum palustre, Müller, 1774; *Lymneus elodes*, Say, 1821 (syntonic form); *L. desidiosus*, Say, 1821 (syntonic form); *Limneus umbrosus*, Say, 1832; *Limnea expansa*, Haldeman, 1840; *L. Nuttalliana*, Lea, 1841; *L. Vahli*, Beck, in Möller, 1842; *L. Pingelei*, Beck, in Möller, 1842; *L. fragilis*, Haldeman, 1842, not *Helix fragilis*, L. = *L. stagnalis*, L.; *L. proxima*, Lea, 1856 (syntonic form); *L.* '*pallida*, Adams', Lea, 1856; *Limnæa Haydeni*, Lea, 1856 (syntonic form); *L. Sumassi*, Baird, 1863 (except front view); *L. Traski*, Tryon, 1863 (syntonic form); *L.* '*reflexa*, Say', Tryon, 1863 (syntonic form); *L. Traski*, Lea, 1864 (not of Tryon, 1863, likewise = *L. palustris*, Müll.); *L. arctica*, Lea, 1864; *L. Rowelli*, Tryon, 1865 (syntonic form);

[1] Professor G. D. Louderback informs the writer that the 'Pliocene' of Cache Valley, Utah, whence this species was described, is, in all probabilities, merely an extension of the Lake Bonneville sediments.

[2] *L. auricularia* is subject to excessive syntonic variation. *L. peregra*, of Europe, and *L. catascopium*, of America, were based on comparatively normal individuals. No attempt is made to give a description broad enough to cover the aberrant forms.

L. Tryonii, Lea, in Tryon, 1865; *L. Tryoniana*, Lea, 1866; *L.* (*Limnophysa*) *Shurtleffi*, Tryon, 1866 (syntonic form); *L. contracta*, Currier, 1872 (syntonic form); *L. Californica*, Sowerby, 1872 (syntonic form); *L. interstriata*, Sowerby, 1872 (syntonic form); *L. palustris*, var. *septentrionalis*, 'Clessin MS.,' Kobelt, 1880; *Leptolimnæa 'Kirtlandiana*, Lea', Keep, 1888 (syntonic form); *Limnæa palustris Michiganensis*, Walker, 1892 (syntonic form); *L. reflexa Jolictensis*, F. C. Baker, 1901 (syntonic form); *L. Leai*, F. C. Baker, 1907 (syntonic form); *L. Danielsi*, F. C. Baker, 1907 (syntonic form); *Galba palustris Alpenensis*, F. C. Baker, 1911 (syntonic form); *G. palustris Blachleyi*, F. C. Baker, 1911 (syntonic form); *G. neopalustris*, F. C. Baker, 1911 (syntonic form).

Shell of moderate size, spire well elevated, whorls moderately inflated, sub-perforate, aperture somewhat narrowly auriculiform, columellar fold well developed; habitat lakes, marshes, and sluggish streams.

Boreal portions of Palæarctic and Nearctic Regions. Entire Californian Province except Los Angeles and Arizona Systems.

Quaternary: Loess of eastern States; Lahontan Lake beds, Nevada; Bonneville Lake beds, Utah; post-Glacial deposits of Vancouver and San Juan Islands.

Lymnæa columella, Say.

Lymnæa columella, Say, 1817; *Limnæa chalybea*, Gould, 1840; *L. casta*, Lea, 1841; *L. Francisca*, Poey, 1858; *L. columella*, var. *Championi*, von Martens, 1899.

Shell rather small for group, fragile, spire somewhat elevated, whorls but little inflated, imperforate, aperture sub-succiniform, columellar fold incipiently developed; habitat quiet waters.

St. Lawrence Basin and Hudson Bay drainage south to Florida and Texas (but absent from Great Plains and east slope of Rocky Mountains), American Province; Gulf of Mexico and Pacific drainages south to Panama, Mexican Province; Antillean Province.

Quaternary: Loess of eastern States.

A primitive species. A rather rudimentary columellar fold is developed, while more or less of the succiniform build of the ancestral Acellinæ is still retained.

Lymnæa reflexa (Say).

Lymneus reflexus, Say, 1821; *L. exilis*, Lea, 1837; *L. Kirtlandiana*, Lea, 1841; *Limnæa lanceata*, Gould, 1848; *L. reflexa scalaris*, Walker, 1892, not *L. scalaris*, Braun, 1853; *L. reflexa Walkeri*, F. C. Baker, 1902; *L. reflexa Hemphilliana*, F. C. Baker, 1904.

Shell of moderate size, solid, spire attenuate, whorls but little inflated, imperforate, aperture succiniform, columellar fold imperfectly developed; habitat lakes and sluggish streams.

St. Lawrence drainage and Mississippi Basin above junction of Ohio and Mississippi Rivers, American Province.

Quaternary: Loess of eastern States.

Likewise a decidedly primitive species; the differential character between these two and *L. stagnalis* is, however, rather one of degree than any tangible distinction.

LYMNÆA MEGASOMA (Say).

Lymneus megasomus, Say, 1824.

Shell very large, solid, bulimuliform, spire elevated, whorls inflated, imperforate, aperture sub-auriculiform, columellar fold well developed or sub-obsolete; habitat lakes and sluggish streams.

Hudson Bay and St. Lawrence drainages, American Province.

A fine large species, which at first glance would hardly seem referable to the same genus as *Lymneus stagnalis*, but connected with it by *L. palustris* and similar forms; in essential particulars it is a true *Lymnæa*. The colouring is unusually pronounced, but *L. reflexa*, likewise a heavy-shelled species, presents much of the same thing.

LYMNÆA CONTRACOSTA, J. G. Cooper.

Limnea Contracosta, J. G. Cooper, 1894.

Shell of moderate size, spire acutely elevated, whorls elongate, rather appressed, and imperforate, aperture succiniform, columellar fold well developed; habitat apparently lacustrine.

Miocene: Contra Costa Lake beds, California; Mascall Lake beds, Oregon.

A species suggesting *L. columella*, but more attenuate, and nearly twice the size, whorls long as in *L. megasoma*. The type was badly crushed, hence the original figure does not portray the specific characters well. The species is not uncommon in the Miocene of the Berkeley Hills, however, so that its recognition is comparatively simple.

LYMNÆA STEARNSI, Hannibal.

Limnæa maxima, Stearns, 1902 (nude name), 1906, figure, not *L. stagnalis* var. *maxima*, Collins, 1872; *L. Stearnsi*, Hannibal in F. C. Baker, 1911 (copy of original fig. of *maxima*, Stearns).

Shell large, spire elevated, whorls inflated and imperforate, aperture sub-auriculiform, columella strongly folded; habitat apparently lacustrine.

Miocene: Mascall Lake beds, Oregon.

A species of the build of *L. palustris*, but decidedly larger and proportionally broader. Stearns' figure is nearly half as large again as the natural size and rather crude.

LYMNÆA COOPERI, n.sp. Pl. VI, Figs. 13*a–c*.

Limnæa '*obrussa*, Say', Tryon, 1865 (*partim*); *L.* '*lepida*, Gould', Carlton, 1870; *Limnophysa* '*ferruginea*, Haldeman', J. G. Cooper, 1870; *L.* '*obrussa*, Say', J. G. Cooper, 1872 (*partim*); *Limnæa* '*obrussa*, Say (*desidiosa*, Say)', Wood & Raymond, 1891; *L.* '*obrussa*, Say', Hannibal, 1910.

Shell small for group, spire acuminate, whorls rather compressed and imperforate, aperture narrowly auriculiform, columellar fold

moderately developed; habitat chiefly mountain streams, less frequently in lakes and ditches.

Type: altitude 11, breadth 5 mm.; altitude of aperture 6·5, breadth of aperture 3 mm. A small specimen: altitude 7, breadth 3 mm. A large specimen: altitude 16, breadth 6 mm.

Coast Range System.

Santa Cruz Mountains, California: Spring, Wrights (type and small cotype) (H. Hannibal); Adobe Creek, near California Camino Real (large cotype) (H. Hannibal, H. M. Edson); creek at Congress Springs (H. M. Edson); San Andreas Reservoir (H. Hannibal); Crystal Springs Reservoir (H. Hannibal); Matedero Creek, near California Camino Real (H. Hannibal, H. M. Edson); Lagunita, Stanford University (Dr. J. P. Smith, R. E. Snodgrass, H. Hannibal, H. M. Edson, S. S. Berry *fide* Berry MS.); San Francisquito Creek, Stanford University (H. Hannibal, H. M. Edson, S. S. Berry *fide* Berry MS.); San Francisco (W. Wood), *fide* Wood & Raymond!; Allanbee Gulch, Portola Valley (H. M. Edson, H. Hannibal); water-trough, Boulder (H. Hannibal); Stone Water-trough Gulch between Boulder and Ben Lomond (H. Hannibal); creeks near Santa Cruz (J. G. Cooper), *fide* Cooper.

Santa Clara Valley: near San Jose (H. Hemphill), *fide* Cooper; near Santa Clara (Miss A. E. Laws); Cottle-Malavous Slough, Artesian Belt (H. Hannibal).

Diablo Range: San Miguel Cañon (Miss A. E. Laws); Tienan's bog, Hall Valley (H. Hannibal); near Oakland, *fide* Tryon.

Gavilan Range: Bird Cañon at forks, 8 miles west of Hollister (H. Hannibal); Tres Pinos Creek, 2 miles south of Tres Pinos (H. Hannibal).

San Joaquin Valley: irrigating ditches near Fresco (C. E. Jenney); slough 8 miles west of Antioch (Miss Ward), *fide* Carlton!

This little *Lymnæa*, abundant in the mountain streams of middle Western California, from its inconspicuous size and general similarity to *L.* (*Galba*) *obrussa*, a species not known to occur within 200 miles, has commonly masqueraded under one or another of the names applied to that species. On careful inspection it may be distinguished by the compressed nearly shouldered whorls, narrower aperture, and entirely different thin gyrate pillar. Carlton's reference of this species to *L. lepida*, Gould, is interesting on account of the general similarity of *Cooperi* to *stagnalis* at one-fourth scale. The writer takes pleasure in perpetuating the name of the late Dr. J. G. Cooper, who, during the last generation, did more than any other writer to make known the freshwater shells of Western North America.

Lymnæa (Galba) truncatula (Müller).

Buccinum truncatulum, Müller, 1774; *Lymneus humilis*, Say, 1822; *L. modicellus*, Say, 1825; *Limnæa umbilicata*, C. B. Adams, 1840; *L. parva*, Lea, 1841; *L. Griffithiana*, Lea, 1841; *L. curta*, Lea, 1841; *L. rustica*, Lea, 1841; *L. exigua*, Lea, 1841; *L. Holbolli*, Beck in Mörch, 1857; *L.* (*Leptolimnea*) *Pilsbryi*, Hemphill, 1890 (syntonic form); *L.* '*desidiosa*, Say', Dall, 1897; *L. Sterkii*,

F. C. Baker, 1905; *L. Owascaensis*, F. C. Baker, 1905; *L. Dalli*, F. C. Baker, 1906; *L. Alamoscnsis*, Arnold, 1907; *L. cyclostoma*, Walker, 1908; *Galba Doddsi*, F. C. Baker, 1911; *G. bulimoides* (*partim*), F. C. Baker, 1911.

Shell of small or moderate size for group, spire elevated or acuminate, whorls well inflated and umbilicate, aperture roundly auriculiform, pillar showing no trace of columellar fold, the reflection of the inner lip broad; habitat generally in marshy situations about lakes or streams, also in mountain brooks and springs, frequently in greenhouses.

Entire Palæarctic and Nearctic Regions, extending south into mountainous portions of Mexican Province.

Quaternary: Loess of eastern States; Lahontan Lake beds, Nevada; calcareous spring deposit, Los Alamos Valley, and alluvial deposits of San Soaquin Valley, California. Miocene: Contra Costa Lake beds, California.

Lymnæa (Galba) obrussa (Say).

Lymneus obrussus, Say, 1825; *L. galbanus*, Say, 1825; *L. plica*, Lea, 1841; *L. exigua*, Lea, 1841; *L. Philadelphica*, Lea, 1841; *L. planulata*, Lea, 1841; *Limnæa ferruginea*, Haldeman, 1841; *L. acuta*, Haldeman, 1842; *L. desidiosa* (*partim*), Haldeman, 1842; *L. desidiosa*, var. *Decampi*, Streng, 1896; *L. 'Adelinæ*, Tryon', Pilsbry, 1898; *L. truncatula*, Dall, 1905 (*partim*); *L. desidiosa*, var. *peninsulæ*, Walker, 1908.

Shell of moderate size, spire elevated or acuminate, whorls somewhat inflated, sub-perforate, aperture narrowly auriculiform, columellar fold nearly or entirely obsolete; habitat streams and lakes on floating algæ or along shore, generally but partially immersed, mountain brooks.

Boreal portions of Nearctic Region extending south to Colorado in Rocky Mountains. Columbia, Utah, and Klamath Systems.

Quaternary: Loess of eastern States; Bonneville Lake beds, Utah.

Reported from Mexico; the record will doubtless prove to have been founded on the preceding species. As with *solida* and the European *glabra*, this Lymnæid is barely beyond the *Lymnæa* stage and hardly a typical *Galba*.

Lymnæa (Galba) caperata (Say).

Lymneus caperatus, Say, 1829; *L. Smithsoniana*, Lea, 1866; *Limnæa Ferrissi*, F. C. Baker, 1902; *L. umbilicata*, *Cubensis*, *Pingelei*, and *opacina* (error for *apicina*) of authors.

Shell of moderate or large size for group, spire bluntly acuminate or sub-pupiform, whorls inflated, marked by spiral fringes of epidermis, and umbilicate, aperture roundly auriculiform, pillar with an obsolete columellar fold; habitat moist places in the vicinity of lakes and sloughs.

Boreal portion of American Province.

Frequently reported from portions of the Californian Province. The records, so far as they have been verified, have proved to have

been based on *solida*, *solida Cubensis*, and *truncatula*. On the other hand *caperata* is frequently identified as one or another of these species. Altogether it is a very badly misunderstood *Lymnæa*.

LYMNÆA (GALBA) SOLIDA (Lea).

Limnæa solida, Lea, 1838; *L. apicina*, Lea, 1838; *L. bulimoides*, Lea, 1841; *L. Adelinæ*, Tryon, 1863; *L. 'ampla*, Mighels', Keep, 1888 (syntonic form); *L.* (*Stagnicola*?) *perpolita*, Dall, 1905 (syntonic form); *L. bulimoides Sonomaensis*, 'Hemphill MS.,' Pilsbry & Ferriss, 1906 (syntonic form); *L. Hendersoni*, F. C. Baker, 1909; *L. Cubensis Sanctijosephi*, Hannibal, 1910 (syntonic form); *Galba 'caperata*, Say', F. C. Baker, 1911 (*partim*).

LYMNÆA (GALBA) SOLIDA CUBENSIS (Pfeiffer).

Limnæa Cubensis, Pfeiffer, 1839; *L. 'caperata*, Say', Tryon, 1863; *L. Lecontei*, Lea, 1864; *L. techella*, Haldeman, 1868; *L. 'humilis*, Say', Keep, 1888; *L. Bryanti*, F. C. Baker, 1905; *L. Cubensis aspirans*, Pilsbry, 1910; *Galba bulimoides Cassi*, F. C. Baker, 1911; *G. 'Galbana*, Say', F. C. Baker, 1911 (*partim*).

Lymnæa solida. Shell of moderate size for group, horny, spire bluntly elevated, whorls inflated, sub-perforate, aperture broadly auriculiform, columellar fold sub-obsolete or (usually) obsolete; habitat lakes and sluggish streams, commonly on floating algæ.

Missouri Basin in American Province. Yukon, Alaska, Fraser, Columbia, Utah, Colorado, Nevada, Klamath, and Coast Range Systems, rarely farther south.

Quaternary: Lahontan Lake beds, Nevada; Christmas Lake beds, Oregon.

Lymnæa solida Cubensis. Shell as in preceding, but porcellanous rather than horny, whorls more inflated, more deeply sutured, and more pronouncedly umbilicate, pillar showing no trace of columellar fold in adult; *solida* stage passed during adolescence; habitat with *Succinea* in moist places, particularly marshes and about the borders of lakes and sluggish streams.

Antillean and Mexican Provinces. Gulf region, and northward to Colorado, west of the Mississippi River in American Province. Arizona, Los Angeles, Mojave, Coast Range, Klamath, Nevada, Utah, and Colorado Systems, infrequently farther to north grading into typical *solida*.

The status of these sub-species has not gained general acceptance since the appearance of the new edition of *West Coast Shells*, in which the writer first pointed out their relationships, due to the extremely involved condition of the nomenclature, while recent work by other writers has hindered rather than assisted in simplifying matters. *Lymnæa solida*, Lea, in violation of the law of priority and common-sense as well, has been treated as a sub-species [*sic!*] of *L. apicina*, a synonym according to every writer in fifty years since it was described some months later from the identical locality, and may be distinguished only by a slightly greater elevation of the spire, and the latter identified with a dwarfed syntonic form of *L. auricularia*

from the Rocky Mountains and Michigan. The original specimens of *solida* and *apicina* came from the present site of Portland, Oregon, or thereabouts, several hundred miles from the nearest point from which *auricularia* has been recorded. According to the figures and original description the types of these two resemble the forms of *auricularia* only superficially, but agree closely with the *Lymnæa*, later called by Lea *L. bulimoides*, under which name this species has been more commonly known.

Not subsequently recognized:

Limnæa bombycina, 'Lunge,' Wood and Raymond, 1891 (nude name).
San Francisco County, California.

Family ANCYLIDÆ, H. & A. Adams, 1855.

Shell of small size, patelliform, crepiduliform, or planorbiform, sinistral or dextral, apex of patelliform genera elevated, medial or posterior, and generally more or less inclined to right or left, spire of planorbiform genera more or less planulate, aperture normally simple; animal sinistral, hermaphroditic, tentacles stoutly triangular, buccal plate with accessory lateral jaws, foot large and oval; habitat lakes and streams.

Four sub-families as follows:—

Sub-family LÆVAPECINÆ, n.sub-fam.

Shell usually large for family, depressed-patelliform; habitat chiefly lacustrine.

Genera: *Lævapex*, *Fisherola*, *Lanx* sub-gen. *Walkerola*.

Sub-family ANCYLINÆ, s.s.

Shell small or of moderate size, elevated-patelliform; habitat lacustrine and fluviatile.

Genera: *Ancylus*, *Zalophancylus*, *Lanx* s.s., *Lævapex* sub-gen. *Ferrissia*, *Gundlachia* sub-gen. *Kincaidilla*.

Sub-family LATIINÆ, n.sub-fam.

Shell small or minute, crepiduliform; habitat chiefly fluviatile.

Genera: *Latia*, *Gundlachia* s.s., *Neoplanorbis* sub-gen. *Amphigyra*.

Sub-family NEOPLANORBINÆ, n.sub-fam.

Shell minute, planorbiform; habitat fluviatile.

Genus, *Neoplanorbis*, s.s.

The genera and species of this family are characterized by their very limited distribution in contrast to nearly all the other aquatic Pulmonata. This, with the simple form and the fact that the distinctive characters lie chiefly in the outline, microscopic sculpture, and position of the apex, has led to a lumping in the genus *Ancylus* of a wide variety of species whose resemblances are due rather to parallel specialization than close affinities.

Genus Gundlachia, Pfeiffer.

Gundlachia, Pfeiffer, 1850 (*G. ancyliformis*, Pfr.); *Poeyia*, Bourguignat, 1862 (*P. gundlachoides*, Bourg.).[1]

Type, *Gundlachia ancyliformis*, Pfeiffer.

Sub-genus Kincaidilla, n.sub-gen.

Type, *Ancylus fragilis*, Tryon.

Ancylus (sp.), Tryon, 1863 (*A. fragilis*, Tryon).

Named after Professor Trevor Kincaid, who has kindly examined this manuscript.

Sub-genus *Kincaidilla*. Shell small, averaging 3 mm. in diameter, patelliform, high-arched, narrowly ovate-elliptical in outline, finely radially and concentrically striate, apex prominent, decidedly subdextral, distinctly posterior, and marked by fine concentric and sub-spirally radial striæ; habitat lakes and streams.

Sub-genus *Gundlachia*, s.s. Shell of small size, averaging 2 or 3 mm. in diameter, growth during first year as in *Kincaidilla*; as animal nears adult condition, however, a septum develops, cutting off the posterior half of aperture, succeeding growth crepiduliform; habitat chiefly streams.

Gundlachia, s.s., needs no introduction, since the group has been a matter of discussion for some years, and it only need be noted that several species from New Zealand, Trinidad, etc., referred here, when the apical sculpture and other characters are studied will almost certainly be found to belong to distinct genera which have reached this same stage of specialization. *Kincaidilla* is instituted to receive certain Nearctic Gundlachias heretofore confused with the Ferrissias, from which they differ in the narrowly elliptical outline and high strongly inclined apex. None of the Ferrissias are known to develop a septum either regularly or infrequently, but it is, apparently, occasionally present in all the Kincaidillas. From septate specimens of *G. fragilis* it appears that this may be due to syntonic influence, at least in certain cases.

Gundlachia (Kincaidilla) fragilis (Tryon).

Ancylus fragilis, Tryon, 1863; *Gundlachia Californica*, Rowell, 1863 (syntonic form); *A. 'patelloides*, Lea', J. G. Cooper, 1872.

Shell minute, elongate, highly arched, apex prominent, decidedly posterior and inclined; habitat streams and (less frequently) ponds, on sticks and submerged vegetation.

Coast Range System.

Genus Lanx, Clessin.

Ancylus (*Velletea*) (sp.), Haldeman, 1844 (*A.* (*V.*) *Nuttalli*, Hald.); *Lanx*, Clessin, 1890 (*A. Newberryi*, Lea = *A. patelloides*, Lea).

Type, *Ancylus patelloides*, Lea.

[1] Juvenile *Gundlachia*, *vide* Crosse & Fischer.

Sub-genus Walkerola, n.sub-gen.

Type, *Lanx Klamathensis*, n.sp.

Named after Mr. Bryant Walker, whose papers on the American *Ancyli* have been of much service in working up the Californian forms.

Sub-genus *Walkerola*. Shell large, averaging 12 mm. in diameter, patelliform, ovate-elliptical in outline, low-arched, coarsely concentrically striate, frequently marked internally by an intermittent radiating white-colour pattern, apex medial, posterior scarcely prominent, smooth or marked by concentric striæ; habitat chiefly lacustro-fluviatile, on rocks and the shells of Naiades.

Sub-genus *Lanx*, s.s. Shell similar to preceding, but decidedly arched and broadly ovate, apex more nearly medial and sub-conspicuous; *Walkerola* stage completed fairly early during adolescence; habitat rapid streams, on rocks and other solid objects.

Lanx (Walkerola) Klamathensis, n.sp. Pl. VIII, Fig. 25.

Ancylus Newberryi of authors, not of Lea.

Shell of moderate or large size, fragile, ovate-elliptical, laterally compressed, low-arched, apex sub-central; habitat lakes and sluggish streams on solid objects.

Type: max. diam. 11, min. diam. 7·5, alt. 3 mm. Cotype: max. diam. 16, min. diam. 9·5, alt. 3·5 mm.

Klamath System in basin of Klamath River, Oregon.

Quaternary: Summer Lake beds, Oregon.

Klamath Valley, Oregon: Government Irrigation Dam, Upper Klamath Lake (types) (E. Applegate, H. Hannibal); Upper Klamath Lake (F. M. Anderson); Link River Rapids, Klamath Falls (E. Applegate, H. Hannibal)[1]; Klamath River, Keno (H. Hannibal); (Quaternary) Summer Lake (F. M. Anderson).

This large low-arched *Lanx* is doubtless present in various collections under the name of *Ancylus Newberryi*, Lea, which was described from (Upper) Klamath Lake. A study of Lea's diagnosis and figure and that given by Binney make it certain that Newberry, who collected the specimens, really obtained them from one of the streams flowing south from Mount Shasta in California, since they are unquestionably merely finely developed dark-coloured *Lanx patelloides*, and very distinct from the present species.

Lanx Nuttalli (Haldeman).

Ancylus (*Velletea*) *Nuttalli*, Haldeman, 1841; *A. crassus*, Haldeman, 1843; *A. Kooteniensis*, Baird, 1865; *A.* '*subrotundatus*, Tryon', Keep, 1888.

Shell small, solid, roundly ovate, slightly broader posteriorly, high-arched, apex posterior; habitat streams.

Columbia System in Columbia River and tributaries.

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[1] One specimen probably washed down from Upper Klamath Lake above.

LANX PATELLOIDES (Lea).

Ancylus patelloides, Lea, 1856; *A. Newberryi*, Lea, 1858; *A. altus*, Tryon, 1865.

Shell large, sub-solid, broadly ovate-elliptical, broader posteriorly, moderately regularly conical, apex sub-central; habitat on rocks in streams.

Klamath System in streams draining into Sacremento River.

LANX SUBROTUNDATUS (Tryon).

Ancylus subrotundatus, Tryon, 1865; *A. patelloides* and *A. Newberryi* of authors, not of Lea.

Shell large, sub-solid, roundly ovate in outline, slightly broader posteriorly, moderately arched, the anterior and posterior slopes gently rounded, apex sub-posterior; habitat streams.

Columbia System in Umpqua River and tributaries.

Very similar to *patelloides*, but less regularly conical, and the apex distinctly posterior.

Genus LÆVAPEX (Walker).

Lævapex, Walker, 1903 (*A. fuscus*, C. B. Ad.).

Type, *Ancylus fuscus*, C. B. Adams.

Sub-genus FERRISSIA, Walker.

Ancylus (sp.), Say, 1819 (*A. rivularis*, Say); ? *Haldemania*, Clessin, 1888 (*A. obscurus*, Hald.), not *Haldemania*, Tryon, 1862; *Ferrissia*, Walker, 1903 (*A. rivularis*, Say).

Type, *Ancylus rivularis*, Say.

Sub-genus *Lævapex*, s.s. Shell of moderate size for group averaging 8 mm. in diameter, patelliform, low-arched, broadly ovate-elliptical in outline, finely radially and concentrically striate, apex sub-dextral, barely posterior, not prominent, and marked only by concentric striæ; habitat chiefly lacustrine.

Sub-genus *Ferrissia*. Shell similar to preceding, but of smaller size, averaging 5 mm. in diameter, patelliform, ovate-elliptical in outline, arched, finely radially and concentrically striate, apex hardly prominent, sub-posterior, and marked by fine concentric and sub-spirally radial striæ; *Lævapex* stage completed during early adolescence; habitat chiefly streams, less frequently in lakes and ponds.

LÆVAPEX (FERRISSIA) CAURINUS (W. Cooper).

Ancylus caurinus, W. Cooper, 1860 (nude name), in Binney, 1865, figure; *A. 'fragilis*, Tryon', Tryon, 1872; *A. 'patelloides*, Lea', J. G. Cooper, 1872; *A. Oregonensis*, Clessin, 1881; *A. caurinus subalpinus*, J. G. Cooper, 1892; *A. rivularis* of authors, not of Say; not *A. 'caurinus*, Coop.', J. Henderson, 1907 = *L. rivularis*.

Shell of moderate size, somewhat elongate, arched, apex sub-posterior, not prominent; habitat streams and ponds on submerged vegetation.

Fraser, Columbia, Utah, Nevada, and Klamath Systems.

Lævapex (Ferrissia) undulatus (Meek).

Ancylus undulatus, Meek, 1877.

Shell large, arched, apex posterior, slightly inclined, sub-prominent; habitat apparently lacustrine.

Eocene: Truckee Lake beds, Nevada.

The internal casts, of which all the specimens seen consist, retain no trace of the sculpture, hence it is difficult to make certain the generic position of this species. Aside from the large size it groups very well with *Ferrissia*, but it is quite unlike the other *Ancylinæ* in the position of the apex.

Genus Neoplanorbis, Pilsbry.

Neoplanorbis, Pilsbry, 1906 (*N. tantillus*, Pils.).

Type, *Neoplanorbis tantillus*, Pilsbry.

Sub-genus Amphigyra (Pilsbry).

Amphigyra, Pilsbry, 1906 (*A. Alabamensis*, Pils.).

Type, *Amphigyra Alabamensis*, Pilsbry.

Sub-genus *Amphigyra*. Shell minute, crepiduliform, dextral, spire lateral, oblique, and smooth, body-whorl spirally striate, aperture large and oblique, a broad concave septum projecting across the posterior portion and reaching up into the spire, indicating an appearance very early in the development; habitat fluviatile.

Sub-genus *Neoplanorbis*, s.s. Shell very minute, planorbiform, dextral, coarsely spirally striate, more or less carinate at periphery, spire sub-planulate, aperture oblique, columellar margin straight; *Amphigyra* stage apparently passed early in development; habitat rapid streams.

Neoplanorbis (Amphigyra) Dalli (White).

Latia Dalli, White, 1882.

Shell large for genus, apex small, terminal, sub-spiral, and slightly oblique, aperture very large; habitat apparently lacustrine, at least in part.

Eocene: Payette Lake beds, Idaho.

This species is known to the writer only from White's original descriptions and figures. It is obviously not a *Latia* nor a *Gundlachia*, but appears to resemble *Amphigyra*, and is placed here tentatively.

Genus Fisherola, n.gen.

Type, *Fisherola lancides*, n.sp.

Shell of moderate size, averaging 6 mm. in diameter, rounded-ovate, somewhat broader anteriorly, depressed-conic, finely concentrically striate, apex small, indistinct; sub-terminal, but not inclined; habitat sluggish streams.

Fisherola agrees with *Lanx*, s.g. *Walkerola*, in general outline, the medial position of the apex, and the absence of radial striæ, while the nucleus (shaped like a Chinese labourer's hat) is very similar, in contrast to *Ancylus*, *Acroloxus*, or any of the Occidental genera.

No one would mistake the two, however, even at first sight, since the apex of *Fisherola* is more posterior than in *Ancylus*, while in *Lanx* it is very nearly central.

Named after Dr. W. K. Fisher, whose frequent criticisms during the preparation of this paper have been much appreciated.

Fisherola lancides, n.sp. Pl. VIII, Fig. 35.

Shell small, fragile, ovate-elliptical, broader anteriorly, low-arched, concentrically striate, apex not inclined, sub-terminally posterior; habitat sluggish streams.

Type: max. diam. 6, min. diam. 3·8, alt. 1·2 mm. Cotype: max. diam. 5·5, min. diam. 4, alt. 1·2 mm.

Columbia System in Snake River Basin.

Snake River, Washington (H. Hemphill).

Genus Zalophancylus, n.gen.

Type, *Zalophancylus Morani*, n.sp.

Shell of large size averaging 9 mm. in diameter, rounded-ovate, regularly elevated-conic, concentrically and apparently radially striate, apex central, large, and prominent, not inclined; habitat apparently lacustrine.

Zalophancylus Morani, n.sp. Pl. VI, Fig. 15.

Shell of moderate size, regularly rounded ovate, elevated conic, apex central and distinctly prominent; habitat apparently lacustrine.

Max. diam. 9, min. diam. 7, alt. 3·5 mm.

Pliocene: Idaho Lake beds, Oregon.

Badland Hills, one mile east of Sand Hollow, Oregon (R. B. Moran).

Named after Mr. R. B. Moran, who collected the type-specimens.

Family PLANORBIDÆ (H. & A. Adams), 1855.

Shell of minute, small, or moderate size, physiform or planorbiform, sinistral or ultra-sinistral,[1] sub-carinate above and below in early stages,

[1] The terms ultra-dextral and ultra-sinistral have seen frequent use in the Lymnoids for genera in which the shell is dextral and the animal sinistral, or vice versa. The explanation of Simroth and others is probably the correct one, however, only in the present and one or two analogous cases. It would be very difficult in the *Kincaidilla* stage of *Gundlachia*, for instance, to explain this phenomenon in such a manner without the animal living up on top of its shell, a feature the writer has never observed. In the primitive Planorbidæ, while the animal is dextral the shell is obviously sinistral. In the more specialized stages an ultra-sinistral shell is developed, doubtless the nearest approach possible to a dextral shell to conform to the dextral animal, but there is no evidence that the ancestral type was ever dextral. The development of *Pompholyx* offers similar difficulties.

In the three patelliform groups of Ancylidæ—*Acroloxus*, *Kincaidilla*, and *Ancylus*, for instance—*Acroloxus* is sub-sinistral, *Kincaidilla* sub-dextral, while *Ancylus* is not distinctly either, yet the animal is sinistral in all cases. It seems, therefore, probable that in this family, groups in the patelliform stages exhibit no constant relation between the position of the apex and the abortion of the soft parts.

The families of the Lymnoideæ have doubtless evolved independently

frequently throughout life, axially and spirally striate, aperture lunate, retracted above, commonly simple, but dentate in one of the modified groups; animal dextral, hermaphroditic, tentacles filiform, buccal plate with accessory lateral jaws, foot quadrate; habitat lakes and streams.

An examination of the early stages of the members of this family reveals the fact that the old classification into *Planorbis* (edentate species) and *Segmentina* (dentate species) has no genetic significance, since the smaller Planorbes with vertically compressed whorls and more or less acute peripherally prove to be congeneric with *Planorbis* (*Segmentina*) *nitida*, as suggested by Ficinus nearly fifty years ago, constituting species which have either never developed apertural teeth or in which they have been absorbed, while the large species, such as *corneus*, *trivolvis*, etc., belong to *Helisoma*.

Both *Planorbis* and *Helisoma* in the primitive condition have a planulate spire and normal umbilicus, and each tends to develop an invaginate spire and planulate umbilicus to accommodate the dextral animal. So many features of unequal parallelism appear, however, that it has not been considered wise to attempt the recognition of stages or sub-families without the study of additional genera.

Genus Planorbis, Müller.

Helix (sp.), Linné, 1758 (*H. planorbis*, L.); *Planorbis* (*pars*), Müller, 1774 (*P. carinatus*, Müll. = *H. planorbis*, L., type by tautonomy); *Planorbarius*, Dumeril, 1806 (emended form); *Anisus* (*pars*), Studer, 1820 (*P. Planorbis*, L., type by substitution); *Spirorbis*, Swainson, 1840 (*P. vulgaris*, Swains. = *H. vortex*, L.), not *Spirorbis*, Daudin, 1800; *Spiralina*, Hartmann, 1840 (nude name); *Tropidiscus*, Stein, 1850 (*H. complanata*, L.= *H. planorbis*, L.); *Gyrorbis*, Moquin - Tandon, 1855 (*P. carinatus*, Müll. = *H. planorbis*, L., type by substitution), not *Gyrorbis*, Fitzinger, 1833; *Omalodiscus*, Benson, 1855 (*P. vulgaris*, Swains. = *H. vortex*, L., type by substitution); *Diplodiscus*, Westerlund, 1897 (*H. vortex*, L.), not *Diplodiscus*, Diesing, 1850; *Spiralina*, 'Hartmann,' Von Martens, 1899 (*H. vortex*, L.); *Paraspira*, Dall, 1905 (*Planorbis rotundatus*, Poir. = *H. vortex*, L.).

Type, *Helix planorbis*, Linné.

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from simple patelliform ancestors, the Ancylidæ illustrating how this has taken place. Assuming that then, as now, the animal in each group was dextral or sinistral as the case might be, while the shells were indiscriminately sub-sinistral or sub-dextral, a ready explanation is afforded. Once the evolution commenced toward the development of a spiral shell, the position of the apex became a matter of the utmost importance, since it determined absolutely whether the coil would be sinistral, dextral, or enveloped by succeeding whorls; consequently a sinistral or dextral, dextral or sinistral shell is superimposed upon a sinistral or dextral animal for all time. In case an unhappy combination resulted the only relief is in ultra-sinistral or ultra-dextral growth to accommodate the animal. This latter phenomenon is genetically distinct and readily detected as such.

Sub-genus Segmentina (Fleming).

Segmentina, Fleming, 1817 (*Planorbis nitidus*, Müll.); *Hemithalamus*, 'Leach MS.,' Turton, 1831 (*Nautilus laeustris*, Lightf. = *P. nitidus*, Müll.), in synonymy; *Discus*, Haldeman, 1840 (*P. armigera*, Say), not *Discus*, Fitzinger, 1833; *Planorbula*, Haldeman, 1842 (*P. armigera*, Say); *Dentatus*, 'Beck,' Gray, 1847 (*P. armatus*, Gray); *Trochorbis*, Benson, 1855 (*P. trochoides*, Bens.); *Appendiculata*, Ficinus, 1867 (*P. nitidus*, Müll., type by inclusion); *Haldemanina*, Dall, 1905 (*P. Wheatleyi*, Lea).

Type, *Planorbis nitidus*, Müller.

Sub-genus Gyraulus, Agassiz.

Nautilus (sp.), Linné, 1758 (*N. crista*, L.); *Turbo* (sp.), Linné, 1767 (*T. nautilus*, L. = *N. crista*, L.); *Planaria*, Brown, 1827 (*Planorbis albus*, Müll.), not *Planaria*, Müll., 1776; *Gyraulus*, Agassiz in Charpentier, 1837 (*P. hispidus*, Drap. = *P. albus*, Müll., type by later designation); *Armiger*, Hartmann, 1840 (*N. crista*, L.); *Troehlea*, Haldeman, 1841 (*P. albus*, Müll., type by substitution); *Nautilina* (sp.), Stein, 1850 (*N. crista*, L.); *Torquis*, Dall, 1905 (*P. parvus*, Say).

Type, *Planorbis albus*, Müller.

Sub-genus Hippeutis, Agassiz.

Hippeutis, Agassiz, in Charpentier, 1837 (*Planorbis complanatus*, Drap. = *Helix fontana*, Lightf.); *Bathyomphalus*, Agassiz, in Charpentier, 1837 (*H. contortus*, L.); *Polygyrus*, Gray, 1847 (*H. contortus*, L.), not *Polygyrus*, Beck, 1837; *Discoidina*, Stein, 1850 (*H. contortus*, L.); *Menetus* (sp.), H. & A. Adams, 1855 (*Planorbis opereularis*, Gould = *P. dilatatus*, Gld.); *Helicorbis*, Benson, 1855 (*P. nitidus*, Gray, *non* Müller = *H. fontana*, Lightf.); *Drepanotrema*, Crosse & Fischer, 1880 (*P. Yzabelensis*, C. & F.); *Heterodiscus*, Westerlund, 1902 (*P. Libanicus*, West.), not *Heterodiseus*, Sharp, 1886.

Type, *Helix fontana*, Lightfoot.

Sub-genus *Planorbis*, s.s. Shell of moderate size, averaging 8 mm. in diameter, discoidal, whorls numerous and vertically compressed, sinistral, spire planulate, umbilicus broadly dished, margin of spire-pit and umbilicus normally subangular, periphery carinate, aperture normal, retracted above; habitat lakes and streams among aquatic vegetation.

Sub-genus *Gyraulus*. Shell similar to *Planorbis*, s.s., but smaller, averaging 5 mm. in diameter, saucer-shaped, whorls moderate in number and vertically deeper, the periphery rounded, growth somewhat ultra-sinistral, spire broadly dished; *Planorbis* stage passed fairly early during adolescence; habitat similar to preceding.

Sub-genus *Segmentina*. Shell similar to preceding but nautiliform, the whorls usually not numerous and vertically deeper, spire-pit broadly funicular, umbilicus more or less depressed, aperture dentate some distance back, the teeth or plaits in two series, one on the

whorl, the other the columella; *Gyraulus* stage passed during early adolescence, *Planorbis* stage pushed back to earliest post-larval growth; habitat similar to preceding.

Sub-genus *Hippeutis*. Shell similar to preceding but lacking the denticulations (which have been absorbed), whorls usually fewer, spire-pit generally narrower and deeper, umbilicus nearly enveloped; *Segmentina* stage apparently passed fairly early during adolescence; habitat same as preceding.

Planorbis has probably suffered worse vicissitudes than any other genus treated in these pages. Not only has it been incorrectly divided, but the group to which the name has been restricted in recent literature belongs to another genus. Müller instituted *Planorbis* in 1774, ostensibly to receive the present families Planorbidæ and Physidæ. No type was designated, since it was not then customary, but the following species were described:—

Section *, shell depressed.

Planorbis contrarius, Müll. (*Helix cornu-arietis*, L., renamed) = *Marissa cornu-arietis* (L.), South American.
P. purpura, Müll. (*H. cornea*, L.) = *Helisoma cornea* (L.).
P. carinatus, Müll. (*H. planorbis*, L.) = *P. planorbis* (L.).
P. vortex, Müll. (*H. vortex*, L.).
P. umbilicatus, Müll. (*H. complanatus*, L.) = *P. planorbis* (L.).
P. spirorbis, Müll. (*H. spirorbis*, L.) = *P. vortex* (L.).
P. contortus, Müll. (*H. contortus*, L.).
P. nitidus, Müll.
P. albus, Müll.
P. imbricatus, Müll. (*Nautilus crista*, L.) = *P. crista* (L.).
P. similis, Müll. = *Helisoma cornea* (L.), juvenile.

Section **, shell conical.

P. bulla, Müll. (*Bulla fontinalis*, L.) = *Physa fontinalis* (L.).
P. turritus, Müll. (*B. hypnorum*, L.) = *Physa hypnorum* (L.).
P. gelatinus, Müll. = ? *Physa fontinalis*, L.

The second section was removed by Müller to *Bulinus* the next year. Lamarck, 1799 and 1801, cites the *Marissa*, an Ampullaroid, the anatomy of which was then unknown, but which has since proved to be very different from that called for in Müller's diagnosis, hence it must be excluded. Swainson (1840), the Adams (1855), and Tryon (1884) give the second species, *Helix corneus* of Linné, as an example, and Dall (1905) cites this as the type. If this were the sum and substance of the matter their example must be followed, and *Planorbis* of future usage, like *Planorbis* of the last seventy years, would be a very different thing from *Planorbis* of Müller, including but two of the original fourteen species, and one of them regarded by the author as doubtfully distinct. Now seven (five, omitting synonyms) of Müller's species are congeneric with *H. planorbis* of Linné, and one is proposed as a substitute for it, the author merely following a current practice of the time of altering the specific name when it became necessary to place the species in a new genus. It seems perfectly

obvious that Müller regarded the smaller Planorbidæ, which formed the bulk of his genus, as the typical members, and utilized the suggestive name of an old well-established species of this group, first described some seventy years before when the binomial nomenclature had not yet come into use, to designate it by. In other words *H. planorbis* is the type of *Planorbis* by tautonomy, and the efforts of Swainson or any other writer fifty or more years later to transfer the name to a different group should not be tolerated. If lack of classical examples is claimed, it might be noted that in 1837 Charpentier, utilizing some of Agassiz's manuscript work, first subdivided the genus as it now stands into natural groups, correctly restricting *Planorbis* to the section including *H. planorbis*, L., and *H. vortex*, L.

The genus *Planorbis* in the sense used here embraces the so-called smaller Planorbes, and is characterized particularly by the peripheral keel in typical *Planorbis*, the simple rounded succeeding stage the denticulations developed in the 'throat' of the shell in the sub-genus *Segmentina*, and a second 'round-whorled' stage following that. These denticules take the form of plaits or cusps, and differ radically in each species, thus affording a ready means of identification, and incidentally several unnecessary sectional names. *P. nitida*, of Europe, has a transverse columellar plait and two on the whorl. The American *P. armigera* is more complex, possessing cusps in addition to the plaits, which are in this instance diagonal. The appearance on looking into the aperture when the shell is oriented in its natural position might be diagrammatically expressed as follows:—

P. nitida. *P. armigera.*

Planorbis (Gyraulus) albus (Müller).

Planorbis albus, Müller, 1774; *P. deflectus*, Say, 1824; *P. hirsutus*, C. B. Adams, 1839; *P. vermicularis*, Gould, 1847; *P. borealis*, 'Loven MS.,' Westerlund, 1875.

Shell small, whorls rounded, fairly deep, and usually more or less hirsute, spire-pit narrow for group; habitat chiefly in lakes, preferring deep water.

Boreal portions of Palæarctic and Nearctic Regions. Yukon, Alaska, Fraser, Columbia, Klamath, and Coast Range (locally) Systems.

Quaternary: Loess of eastern States.

Planorbis (Gyraulus) parvus (Say).

Planorbis parvus, Say, 1817; *P. glaber*, Jeffreys, 1820; *P. levis*, Alder, 1838; *P. elevatus*, C. B. Adams, 1840; *P. vermicularis* of authors in part, not of Gould.

Shell small, whorls compressed, spire-pit widely evenly concave; habitat lakes and streams.

Nearctic Region; European Province.

Quaternary: Loess of eastern States; post-Glacial deposits of Vancouver and San Juan Islands; San Pedro formation (specimens washed into marine terraces), alluvial deposits of San Joaquin Valley, Owen Lake beds, playas of Mojave Desert, and Le Conte Lake beds, California.

PLANORBIS (GYRAULUS) LIEBMANNI (Dunker).

Planorbis Liebmanni, Dunker in Martini & Chemnitz, 1850; *P. gracilentus*, Gould, 1855.

Shell of large size, whorls fairly deep, spire-pit rather broadly concave; habitat lakes and streams.

Mexican and Antillean (?) Provinces. Arizona System (locally).

Le Conte Lake beds, California.

Probably not the earliest name for this species; the Mexican Planorbidæ are in need of careful revision.

PLANORBIS (GYRAULUS) FILOCINCTUS (Pilsbry & Ferriss).

Planorbis filocinctus, Pilsbry & Ferriss, 1906.

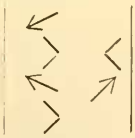
A species of the type of *P. albus* and *P. parvus*, but unknown to the writer except from the original diagnosis in the *Mollusca of the South Western States*, part ii.

Arizona System.

PLANORBIS (SEGMENTINA) ARMIGERUS (Say).

Planorbis armigerus, Say, 1821.

Shell of moderate size, whorls fairly deep, umbilicus and spire-pit broad, the latter deep, aperture armed, the teeth corresponding to the formula

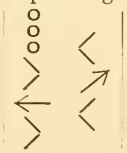


habitat sluggish streams and marshes.

American Province. Yukon System.

PLANORBIS (SEGMENTINA) MOJAVENSIS, n.sp. Pl. VIII, Fig. 27.

Shell large, nautiliform, whorls rounded, deep, not numerous, umbilicus and spire-pit broad, and nearly equal in depth, aperture armed, the denticulations corresponding to the formula



habitat probably lacustrine.

Diam. 9·5, alt. 4·5, diam. of aperture 3 mm.

Miocene: Rosamond Series, California.

Near Barstow, Mojave Desert, California (J. C. Merriam, C. L. Baker).

Resembles *P.* (*Hippeutis*) *contortus* of Europe, somewhat in the nautiliform shape, but decidedly larger, and lacking the numerous whorls of that species. The absence of apertural lamellæ above the periphery on the whorl is peculiar, but characteristic of all the specimens in which this character may be made out.

Planorbis (*Segmentina*) *declivis* (Tate), 1870.

Dall (*Alaska*, xiii, 1905, p. 98) cites this Nicaraguan species from the Umpqua River, Oregon. In several years field-work in California and Oregon the writer has seen nothing corresponding to it, and the species does not appear on a manuscript list of the shells observed in the vicinity of Elkton on the Umpqua River by Fred H. Andrus, an old collector. Is this not another *Unio Oregonensis*?

Planorbis (Hippeutis) exacutus (Say).

Planorbis exacuous (misprint for *exacutus*), Say, 1821; *P. exacutus*, 'Say' of authors.

Shell of moderate size, whorls vertically compressed, spire-pit broad for group, umbilicus not appreciably depressed; habitat ponds and streams.

American Province. Yukon, Fraser, and Columbia (locally) Systems.

Loess of Yukon Valley, Alaska.

Planorbis (Hippeutis) dilatatus (Gould).

Planorbis lens, Lea, 1838, not of Brongniart, 1810; *P. dilatatus*, Gould, 1841, not of Pfeiffer, 1842; *P. lenticularis*, Lea, 1844, not of Schlotheim, 1818; *P. Buchanensis*, Lea, 1844; *P. Brongniartiana*, Lea, 1844; *P. opercularis*, Gould, 1847 (syntonic form); *P. planulatus*, W. Cooper, 1860 (syntonic form); ? *P. 'gracilentus*, Gould', Tryon, 1863; *P. Centervillensis*, Tryon, 1872; *P. callioglyptus*, Vanatta, 1895 (syntonic form); *P. opercularis*, var. *Oregonensis*, Vanatta, 1895, not *P. Oregonensis*, Tryon, 1865 = *H. trivolvis*, Say; *P. opercularis*, var. *multilineata*, Vanatta, 1899; *P. Vanvlecki*, Arnold, 1910 (syntonic form); *P. vermicularis* of authors in part, not of Gould.

Shell small or of moderate size, whorls deep, spire-pit narrow but extending to apex, umbilicus not appreciably depressed; habitat lakes and clear streams.

European and American Provinces. Entire Californian Province except Los Angeles and Arizona Systems.

Quaternary: Lahontan Lake beds, Nevada; Owens Lake beds and alluvial deposits of San Joaquin Valley, California; Summer and Christmas Lake beds, Oregon. Pliocene: Idaho Lake beds, Oregon and Idaho; Kettleman Lake beds, California.

A common species in the Californian Province, but sporadic elsewhere if the records may be depended upon. Besides being reported under a variety of names it has doubtless been confused with the preceding species, which is less common west of the Rocky Mountains.

P. Samsoni, Ancey, and *Alabamensis*, Pils., are two of the better known synonyms, which have, however, not been used for the species in the present district.

'*Planorbis* (*Spirorbis*)' *lunatus*, Conrad, 1871.

Oligocene: John Day Series, Oregon.

This is not a *Planorbis*, as supposed by Conrad, but a land snail belonging to the genus *Ammonitella* of J. G. Cooper. Stearns, apparently unaware of Conrad's name, redescribed the species in 1900 as *Ammonitella Yatesi præcursor*. *Ammonitella lunata* is, however, specifically distinct from *A. Yatesi*, a recent species from the Sierra Nevada Mountains, California.

Genus Helisoma, Swainson.

Helisoma, Swainson, 1840 (*Planorbis bicarinatus*, Sowb. = *P. antrosus*, Conr.); *Taphius*, H. & A. Adams, 1855 (*P. andecola*, d'Orb.).

Type, *Planorbis antrosus*, Conrad.

Sub-genus Planorbella, Haldeman.

Helix (sp.), Linné, 1758 (*H. cornea*, L.); *Planorbis* (sp.), Müller, 1774 (*P. purpura*, Müll. = *H. cornea*, L.); *Planorbella*, Haldeman, 1842 (*P. campanulatus*, Say); *Planorbina*, Haldeman, 1842 (*P. olivaceus*, Spix, cited by Dall, 1905); *Coretus*, 'Adanson,' Gray, 1847 (*H. cornea*, L.); *Menetus*, H. & A. Adams, 1855 (for '*Anisus*, Beck, not Fitz.', hence *P. olivaceus*, Spix); *Adula*, H. Adams, 1861 (*P. multivolvis*, Case = *P. campanulatus*, Say, syntonic form), not *Adula*, H. & A. Adams, 1851; *Anceus*, H. Adams, 1869 (for *Adula*, H. Adams, hence same type), not *Anceus*, Fauvel, 1863; *Pierosoma*, Dall, 1905 (*P. trivolvis*, Say).

Type, *Planorbis campanulatus*, Say.

Sub-genus Perrinilla, n.sub-gen.

Type, *Helisoma Cordillerana*, n.sp.

Named in honour of Dr. James Perrin Smith, to whom the writer is under obligations for frequent advice, particularly pertaining to the theoretical problems, during the preparation of this paper.

Sub-genus *Planorbella*. Shell large, averaging 20 mm. in diameter, whorls moderately deep, sinistral, the spire planulate, tending to become excavated as the adult condition is reached, its margin sub-carinate, umbilicus narrow and deep, broadening rapidly during later development, margin subangular, aperture retracted above, expanded in adult; habitat lakes and quiet streams.

Sub-genus *Helisoma*, s.s. Shell similar to *Planorbella*, but distinctly ultra-sinistral, the spire-pit and umbilicus funicular, and nearly equal in depth, each margined by a decided peripheral carina, aperture expanded in adult; *Planorbella* stage passed very early during adolescence; habitat similar to *Planorbella*.

Sub-genus *Perrinilla*. Shell similar to *Planorbella*, except that it is totally ultra-sinistral, spire-pit deep and narrow, umbilicus but slightly excavated, superior and inferior peripheries subangular; *Helisoma* stage passed very early during adolescence, *Planorbella*

stage not distinguished on account of preservation; habitat apparently similar to *Planorbella*.

Nearly every well-established recent species of this genus has apparently served as the type of its own peculiar sub-genus. The present arrangement is not liable to offer particular difficulties to American conchologists, but the *Planorbella* group is commonly known in Europe under the name of *Corteus*. This was originally used by Adanson (as *Coretus*) in a somewhat different sense, but on its introduction into Linnean nomenclature it was transferred to the present group. Since this did not take place until after the appearance of *Planorbella* it must be suppressed, a procedure that the writer is not sorry for on historical grounds.

Helisoma appears to be a Mesozoic genus, which reached its culmination in the older Tertiary or earlier, and is represented in the living state chiefly by species belonging to the primitive group. *Perrinilla*, which would doubtless be termed by Grabau a 'second round-whorled stage', appears to be an instance of over-specialization resulting in extinction.

HELISOMA (PLANORBELLA) TRIVOLVIS (Say).

Planorbis trivolvis, Say, 1817; *P. tumidus*, Pfeiffer, 1839 (syntonic form); *P. 'corpulentus*, Say', Haldeman, 1844 (syntonic form); *P. 'glabratus*, Say', Haldeman, 1844 (*partim*); *P. ammon*, Gould, 1855 (syntonic form); *P. subcrenatus*, Carpenter, 1856 (senile); *P. Traski*, Lea, 1856 (syntonic form); *P. tumens*, Carpenter, 1857 (syntonic form); *P. truncatus*, Miles, 1861 (syntonic form); *P. Horni*, Tryon, 1865 (syntonic form); *P. Oregonensis*, Tryon, 1865 (syntonic form); *P. Binneyi*, Tryon, 1868 (syntonic form); *Helisoma 'tennis*, Phil.', Carlton, 1870 (syntonic form); *P. occidentalis*, J. G. Cooper, 1870 (syntonic form); *H. plexata*, Ingersoll, 1874 (syntonic form); *P.* (*subcrenatus*, var.?) *disjectus*, J. G. Cooper, 1890 (syntonic form); *P. 'lentus*, Say', Stearns, 1893 (syntonic form); *P. 'vermicularis*, Gould', Arnold, 1903.

Shell large, coarsely striate, whorls deep, not numerous, superior margin sub-prominently carinate, forming an evenly concave spire-pit, aperture somewhat expanded in adult; habitat lakes and sluggish streams.

Entire Nearctic Region. Mexican Province.

Quaternary: Loess of eastern States; San Pedro Formation (specimens washed into marine terraces), alluvial deposits of San Joaquin Valley, and Le Conte Lake beds, California; Lahontan Lake beds, Nevada; Bonneville Lake beds, Utah; post-Glacial deposits of Vancouver Island. Pliocene: Santa Clara and Cache Lake beds, California.

HELISOMA ANTROSA (Conrad).

Planorbis bicarinatus, Say, 1817, not of Lamarck, 1804; *Helix angulata*, Rackett, 1821, not of Burrow, 1815; *P. antrosus*, Conrad, 1834; *P. elongatus*, Conrad, 1835; *P. bicarinatus*, Sowerby, 1840, not of Lamarck, 1804; *P. angistoma*, Haldeman, 1844; *P. lautus*, H. Adams, 1861.

Shell rather small, finely striate, whorls deep and of moderate size, umbilicus and spire-pit prominently funicular, the former particularly so, superior and inferior peripheries pronouncedly carinate, aperture expanded in adult; habitat lakes and quiet streams.

American Province. Columbia and Fraser Systems.

Quaternary: Loess of eastern States.

Helisoma (Perrinilla) Pabloana (J. G. Cooper).

Planorbis Pabloanus, J. G. Cooper, 1894.

Shell small, coarsely striate, whorls not deep and rather small, umbilical carina nearly obsolete, sub-marginal, the umbilicus unevenly concave, spire-pit rather broad for group, aperture but slightly expanded; habitat apparently lacustrine.

Miocene: Contra Costa Lake beds, California.

A small inconspicuous species lacking the evenly dished umbilicus of *Cordillerana*. The type was crushed flat, and alone would hardly be sufficient to distinguish the species if still in existence. Several fairly preserved specimens from the vicinity of the original locality permit a diagnosis, however.

Helisoma (Perrinilla) Cordillerana, n.sp. Pl. IV, Fig. 34; Pl. VI, Fig. 16.

Shell of considerable size, whorls large, somewhat compressed, and strongly ultra-sinistral, the umbilicus barely concave, superior and inferior peripheries subangular in young stages, becoming rounded in adult, growth-striæ strong, spiral striæ occasionally preserved, aperture expanded somewhat in adult; habitat apparently lacustrine.

Diam. 22, alt. 9, diam. of aperture 12 mm.

Eocene: Truckee Lake beds, Nevada.

Hill near Hawthorne on the Belmont stage road (types); near Hawthorne (probably same locality) (H. W. Turner); one mile south-east of coal-mine, Silver Peak Range (S. A. Knapp, H. W. Turner); 1½ miles south-east of coal-mine (H. W. Turner); hill immediately back of coal-mine (H. W. Turner); 7·7 km. north-east of Emigrant Gap, and 8·6 km. south-east of coal-mine, Silver Peak Range (H. W. Turner).

Possibly co-specific with *Planorbis Utahensis*, Meek, from the same horizon in the Rocky Mountains. The species belongs to this group, but the figures are not characteristic and no specimens are available.

Family POMPHOLIGIDÆ, Dall, 1866.

Shell of small or moderate size, velutiniform or sub-planorbiform, dextral, showing fine spiral and growth striæ, aperture ovate or ovate-quadrate, columella simple, imperforate, or umbilicate; animal sinistral, hermaphroditic, tentacles clavate, buccal plate sub-cordiform, lateral jaws absent, foot quadrate-elliptical; habitat lakes and clear streams.

The genus *Pompholyx*, the sole known representative of this family and a strictly Californian group, contains four Cenozoic species which differ rather widely in superficial appearance, and with the exception of the recently described *P. Sanctæclaræ* have served as the types of